EMF 22: Climate Policy Scenarios for Stabilization and in Transition,
Tsukuba International Congress Center (Epochal)
Tsukuba, Japan
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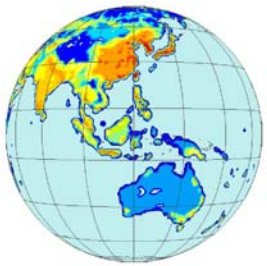
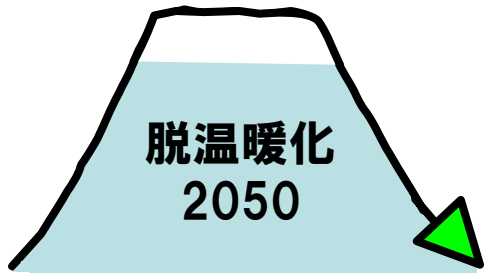


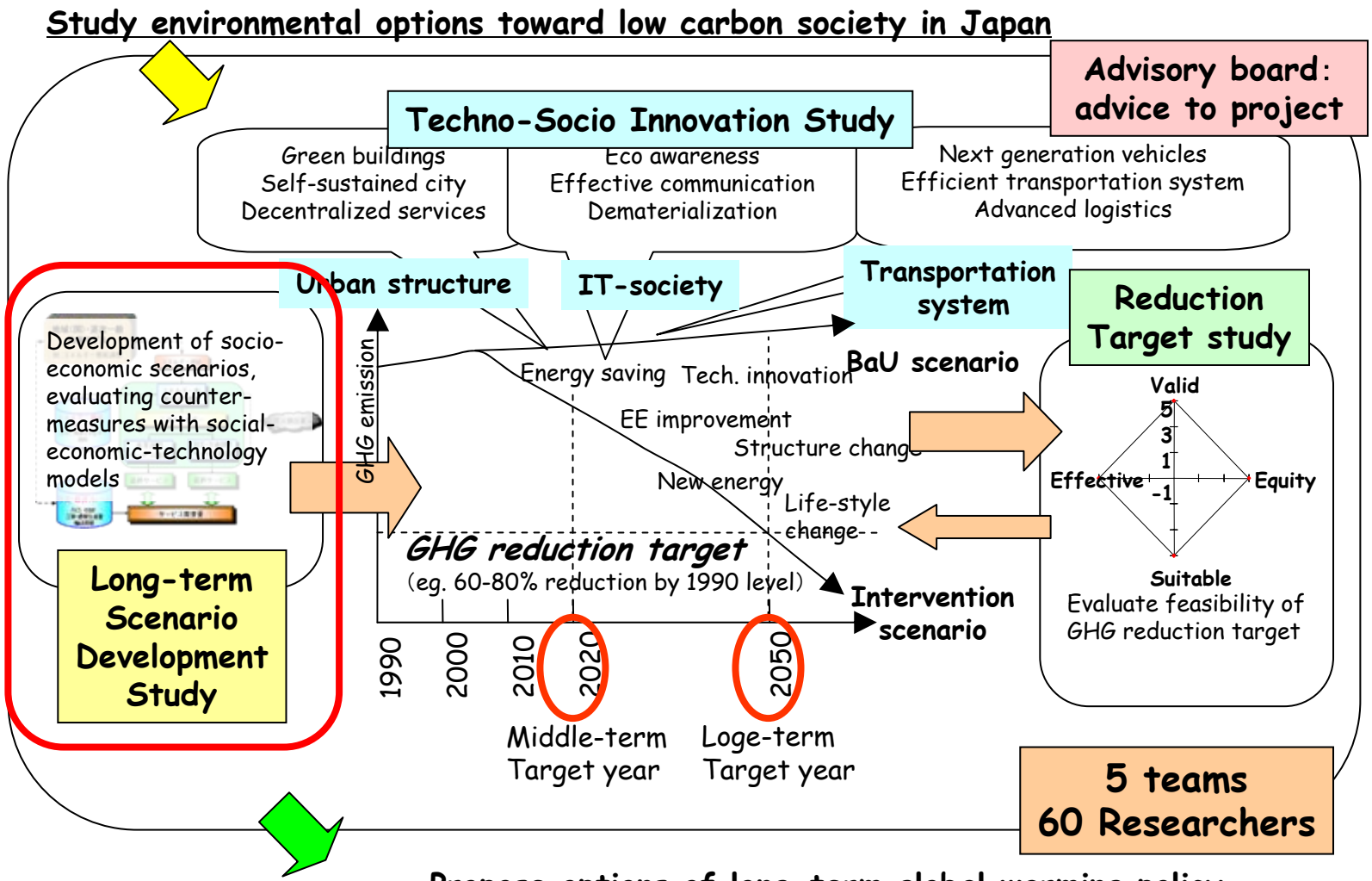
Modeling in Japan "LCS toward 2050" project

Yuzuru Matsuoka
Kyoto University



Japan Low Carbon Society Scenarios toward 2050

[FY2004-2006(+2years), Global Environmental Research Program, MOE]



Focusing points of LCS modeling study

1. Support to develop LCS scenarios which satisfy the prescribed emission targets as well as the related environmental, economical and social targets.

2. The scenarios are concrete, plausible, quantitative and consistent with technology, economy and sociality.

3. However, the LCS may be far from the current trend, and in order to reach them, the models can be useful to search "Trend Breaking Interventions" and to estimate their effects from the viewpoint of technological, environmental, and economical aspects.

Models to support LCS study

Element models;

1) Snapshot models;

Quasi steady Computable General Equilibrium (CGE) model
Energy technology bottom-up models, energy supply model
Household production/lifestyle model
Transportation demand model

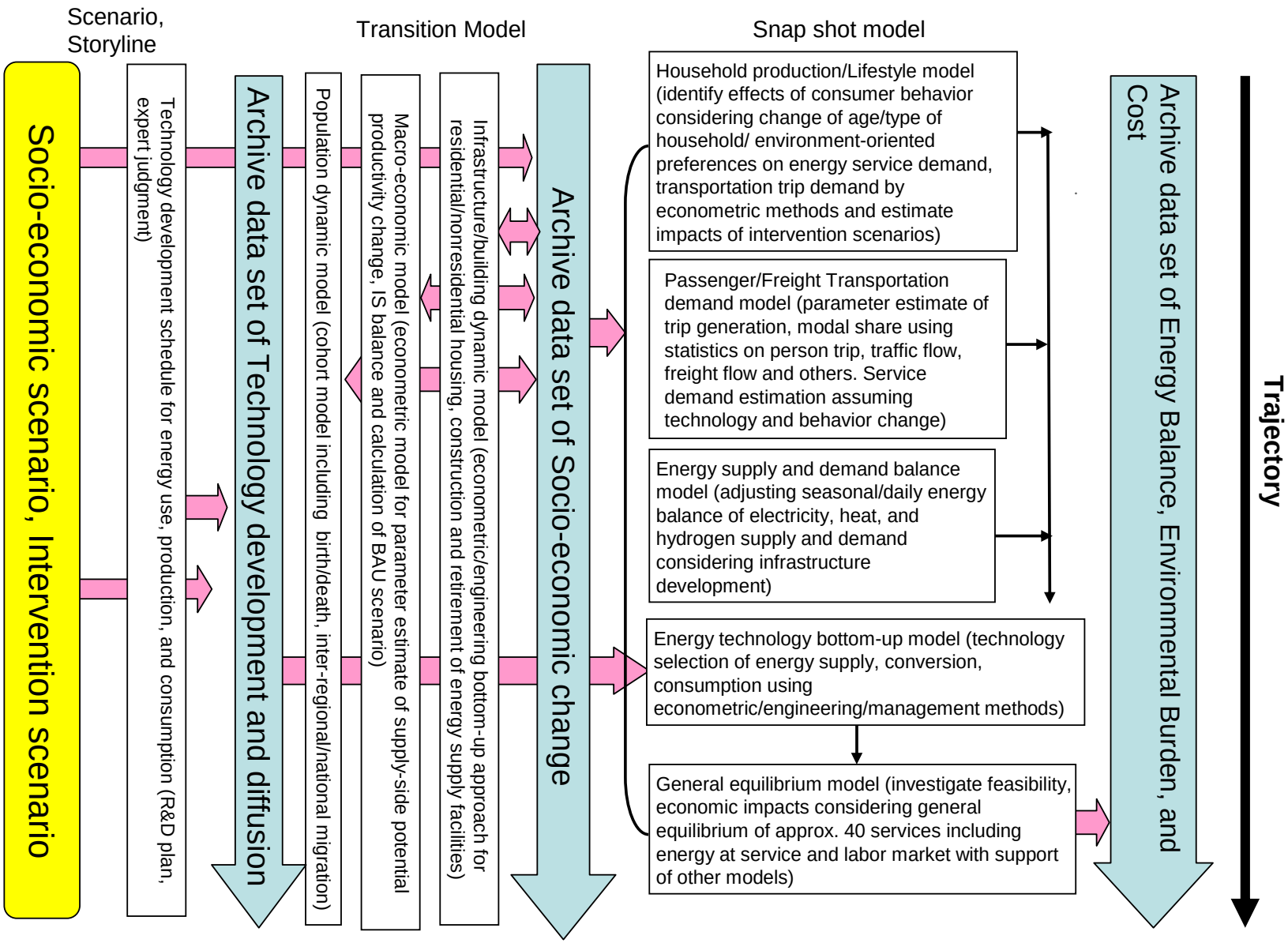
2) Transition models;

Population and household model
Building dynamics model
Econometric type macro-economic model

Integration models;

Snapshot Integration Tool (SSI)
Backcasting Model for transient control (BCM)

Element models for Japan low carbon society project



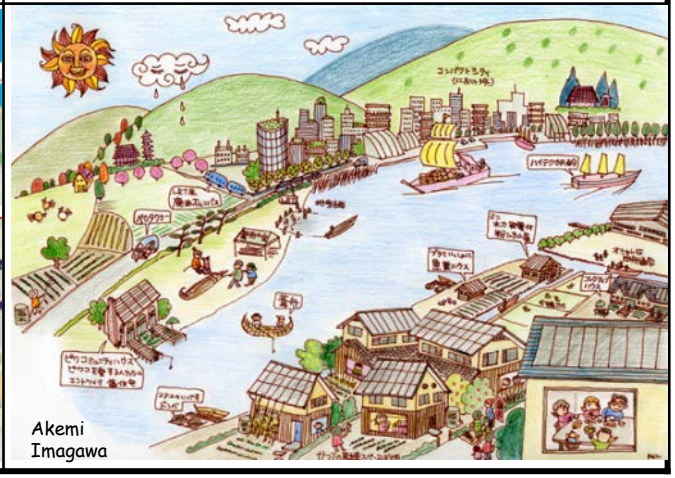
Using these models, and in order to describe the plausible, feasible, and consistent future, we are proceeding the study in the following steps

1. Description of narrative scenarios and storylines, supported by project members, the advisory board, interviews to experts.

2. Construction of socio-economic visions in 2050 quantitatively, which satisfy 60-80% reduction of CO_2 emission constraints.

3. Identification and evaluation of required interventions (Trend Breaking Interventions) that induce the society to LCS.

As for LCS visions, we prepared two different but likely future societies

Vision A "Doraemon"	Vision B "Satsuki and Mei"
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
	

Doraemon is a Japanese comic series created by Fujiko F. Fujio. The series is about a robotic cat named Doraemon, who travels back in time from the 22nd century. He has a pocket, which connects to the fourth dimension and acts like a wormhole.

Satsuki and Mei's House reproduced in the 2005 World Expo. Satsuki and Mei are daughters in the film "My Neighbor Totoro". They lived an old house in rural Japan, near which many curious and magical creatures inhabited.

Narrative description of Scenario A

Technical progresses in the industrial sectors are considerably high because of vigorous R&D investments by the government and business sectors. The economic activities as a whole are so dynamic that average annual per capita GDP growth rate is kept at the level of 2%. The other reasons for such high economic growth are high rates of consumption in both business and household sectors.

The employment system has been drastically changed from that in 2000 and equal opportunities for the employment have been achieved. Since workers are employed based on their abilities or talents regardless of their sex, nationality and age, the motivation of the worker is quite high in general.

As many women work outside, the average time spent for housekeeping has decreased. Most of the household works are replaced by housekeeping robots or services provided by private companies. Instead, the time used for personal career development has increased.

The new technologies, products, services are positively accepted in the society. Therefore, purchasing power of the consumer is strong and upgrade cycles of the commodities are short.

Household size becomes smaller and the number of single-member households has increased. Multi-dwellings are preferred over detached houses, and the urban lifestyle is more popular than the lifestyle of countryside.

Narrative description of Scenario B

Although average annual growth rate of per capita GDP is approximately 1%, people can receive adequate social services no matter where they live. Volunteer works or community based mutual aid activities are the main provider of the services. Since the levels of medical and educational service in the countryside have drastically improved, continuous migration of population from city to countryside has been observed.

The number of family who own detached dwellings has increased. The trend is especially prominent in the countryside. The size of the houses and the floor area per houses has also increased with the increasing share of detached houses.

The ways people work have also changed. The practice that husbands work outside and wives work at home is not common anymore. In order to avoid the excessive work of the partner, the couples help each other and secure the income according to their life plan. Housework is shared mainly among family members, but free housekeeping services provided by local community or social activity organizations are also available. As a result of the changes in lifestyle, the time spent within family has increased. The time spent on hobby, sports, cultural activities, volunteer activities, agricultural works, and social activities has also increased.

Quantify impacts of social economic changes to energy service demand with models

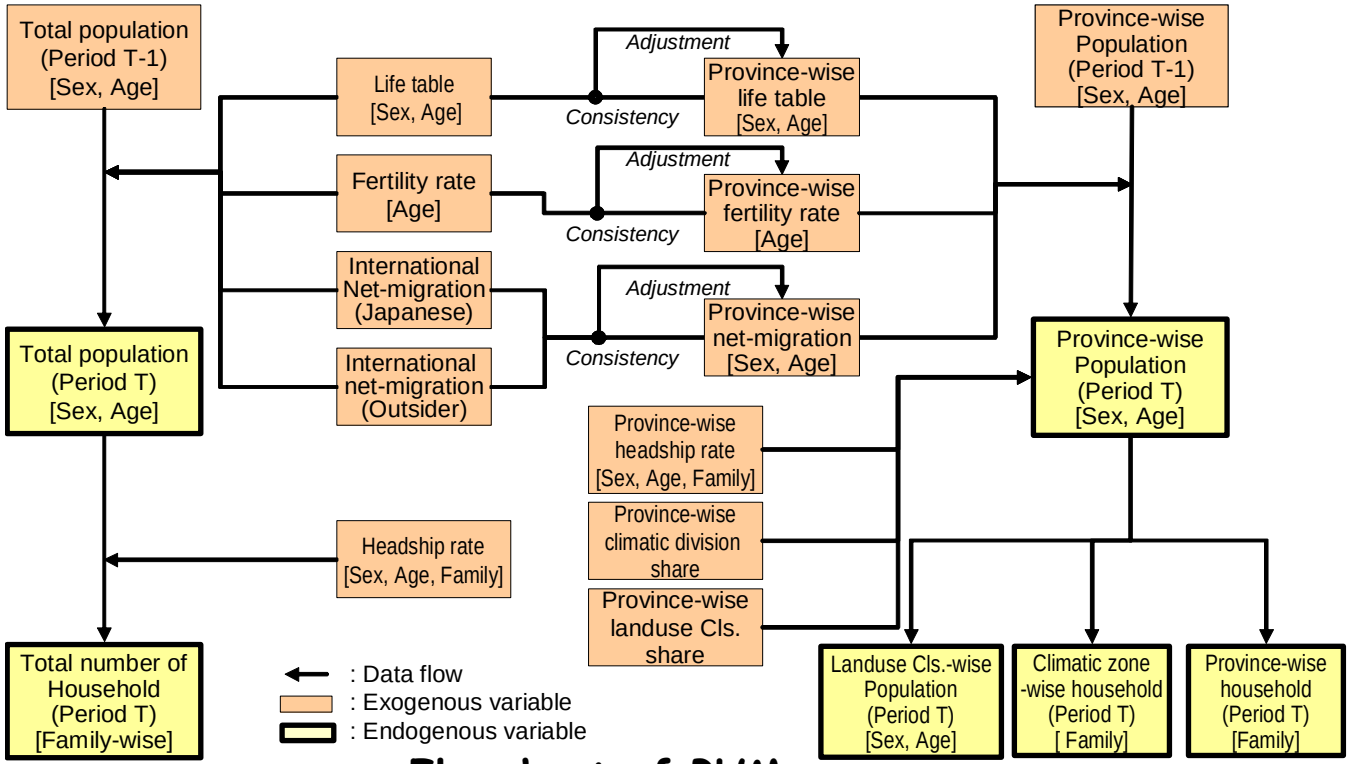
	Items to be considered		Developed Models
Industry	a. Changes in industrial structure and technological development on energy consumption as well as productivity	-	Inter-sector and Macro Economic Model
Domestic and Commercial	b. Changes in building distribution by climatic zone	-	Building Dynamics Model (b-e)
	c. Changes of the share of detached and multidwelling houses	-	Household Production and Lifestyle Model (f)
	d. Diffusion rate of insulated detached and multidwelling houses		
	e. Lifetime changes of the dwellings		
	f. Lifestyle changes on household consumption and allocation of the time		
Transportation	g. Changes in population distribution and local characteristics	-	Passenger Transportation Demand Model (g-i)
	h. Changes in social environment and human activities	-	Freight Transportation Demand Model (j-m)
	i. Changes in selectivity of the mode of passenger transportation by area		
	j. Changes in industrial structure		
	k. Dematerialization		
	l. Changes in producing/consuming area		
	m. Changes in selectivity of the mode of transportation by distance		
Energy supply	n. Function of load management and uncertainties of both energy supply and demand	-	Energy Supply and Demand Balance Model (n-p)
	o. Combination of small consumer and small energy sources + Electricity/Hydrogen		
	p. Feasibility of local production for local consumption		
Social system	q. Relationship between economic activities and stock/flow of the materials	-	Material Stock and Flow Model (q-s)
	r. Amount of waste derived from the stock		
	s. Effectiveness of recycling and its impacts		
Cross-sectional	t. Ensuring consistency among the sectors in terms of energy demand and supply	-	Energy Snapshot Tool (t)
	u. Impacts of future technological choices on social energy efficiency	-	EDB (u)
	v. Ensuring economical consistency of LCS	-	Inter-sector and Macro Economic Model (v)

On these two scenarios, we allocate possible trend-breaking options

Sector	Scenario A	Scenario B
Industry	· Energy efficient production technology	· Energy efficient production technology
Residential and Commercial	· Insulation of the building · Diffusion of all-electric home · Diffusion of high efficiency heat pump air conditioner and water heater · Development and diffusion of fuel cells · Optimal energy control by HEMS	· Insulation of the building · Installing PV (especially in detached houses) · Use of biomass fuels for cooling · Diffusion of solar water heating · Education (Eco life navigation system)
Transportation	· Shortening trip distance for commuting by intensive land use · Modal shift from cars to mass transit systems (buses, railways, LRTs) · Diffusion of motor drive cars such as electric vehicles and fuel cell vehicles	· Urban structures becoming more compact · Infrastructure development for foot and bike passengers (sidewalk, bikeway, cycle parking) · Diffusion of biomass hybrid cars · Modal shift from cars to railways and to ship for freight transportation
Energy supply	· Expansion of nuclear power generation · Electric load levelling and expansion of electric storage (ex. Store the electricity generated in night time and use it for electric vehicles · High efficient fossil fuel technologies+CCS · Hydrogen production from fossil fuel+CCS · Infrastructure development for hydrogen production, transportation, storage, application	· Expansion of renewable energy use (wind, photovoltaic, solar thermal, biomass) · Application of Information technologies (IT) for load adjustment
Stock and waste management	· Less material use for production by technology development · Advancement of recycling technologies	· Expanding lifetime of the goods · Decrease in final demand due to departure from material wealth yardsticks · Recycled product preference of the consumer

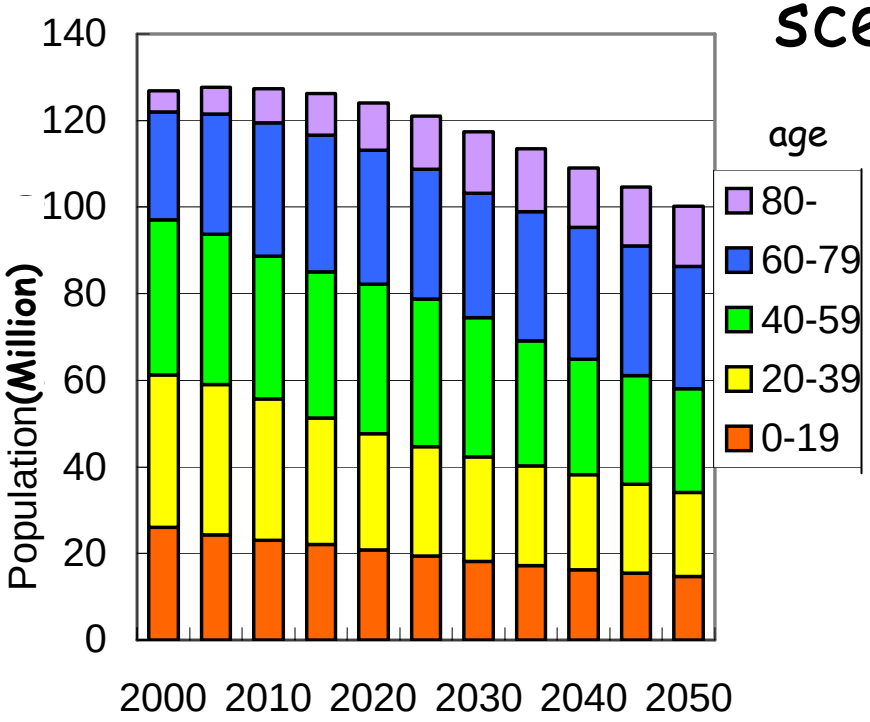
Population and Household Model

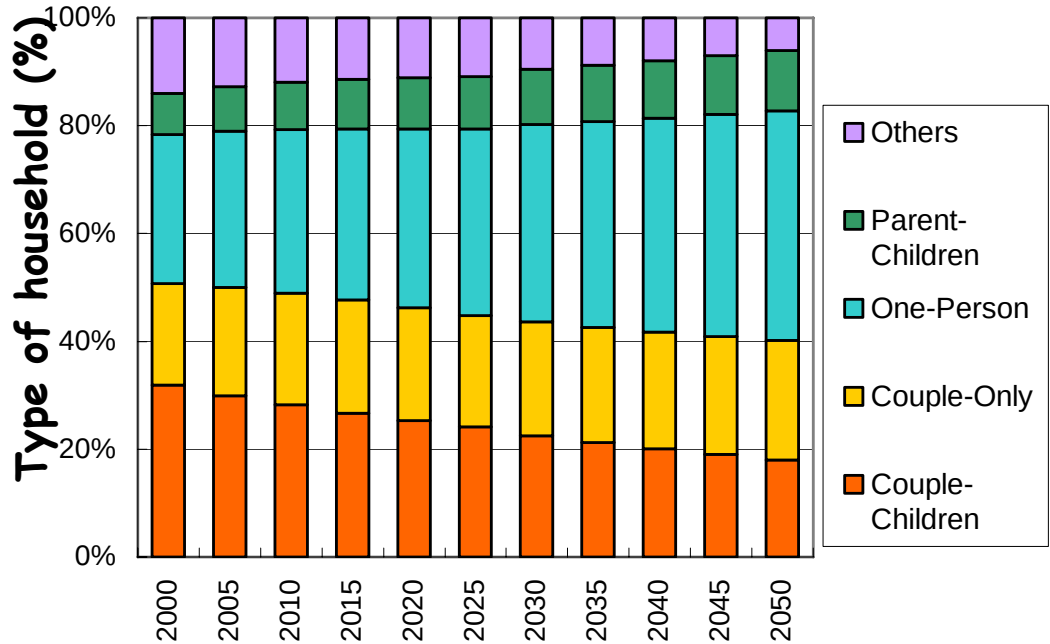
- Drastic change is projected in Japan's population structure by 2050. Downturn in birthrate, depopulation and aging will continue until 2050, and they affect greatly the future vision.
- A cohort component model for population, a household headship rate model for household types, with spatial resolution 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.



Flowchart of PHM

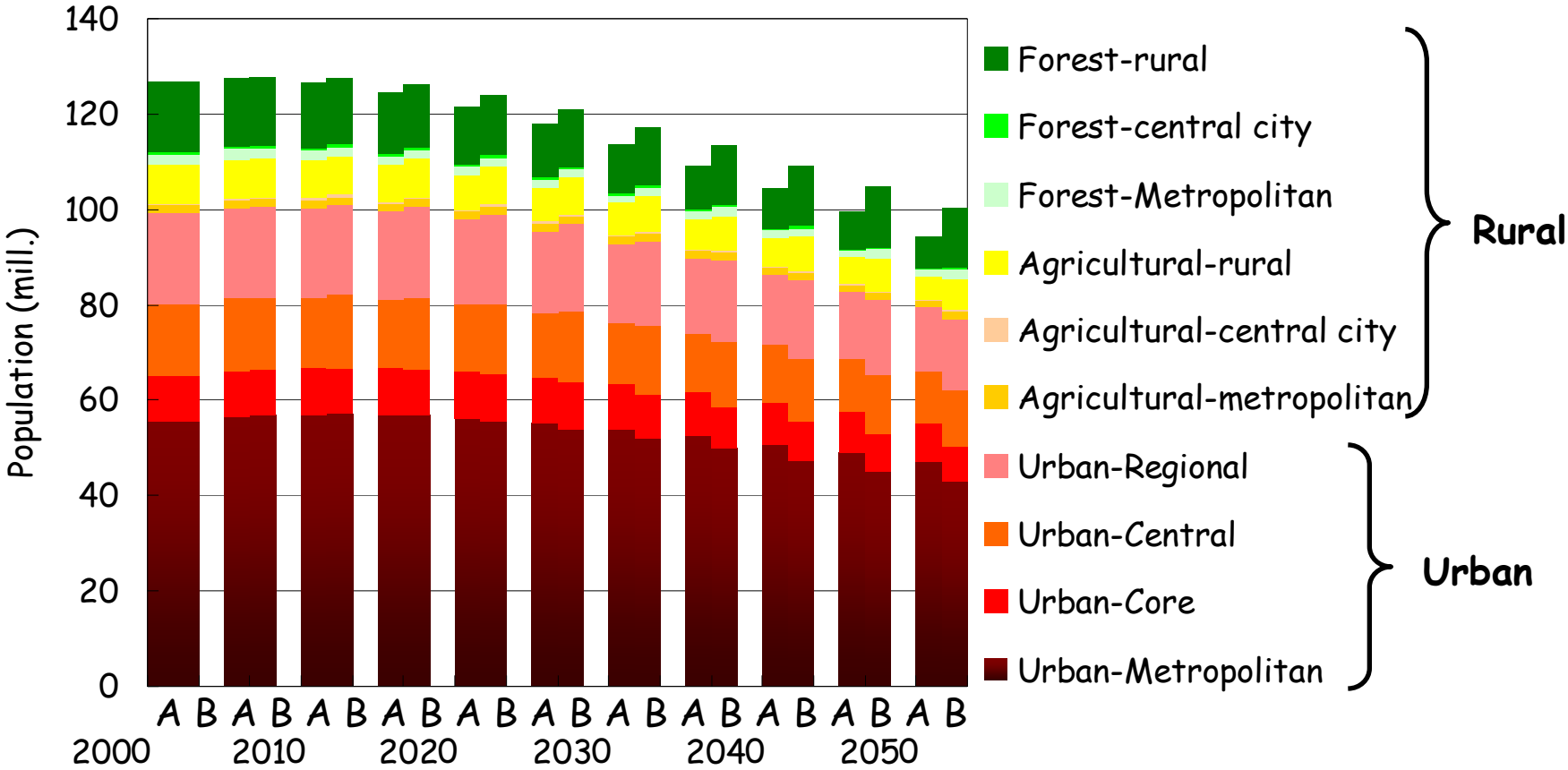
Projection Japan population and households in scenario A





year	2000	2050	
		A	B
Population (million)	126.9	94.5	100.3
Aged population ratio (%)	17.4	53.7	35.8
Average number of household	2.71	2.19	2.38
Single-person households (%)	27.6	42.6	35.1

Projection of urbanization



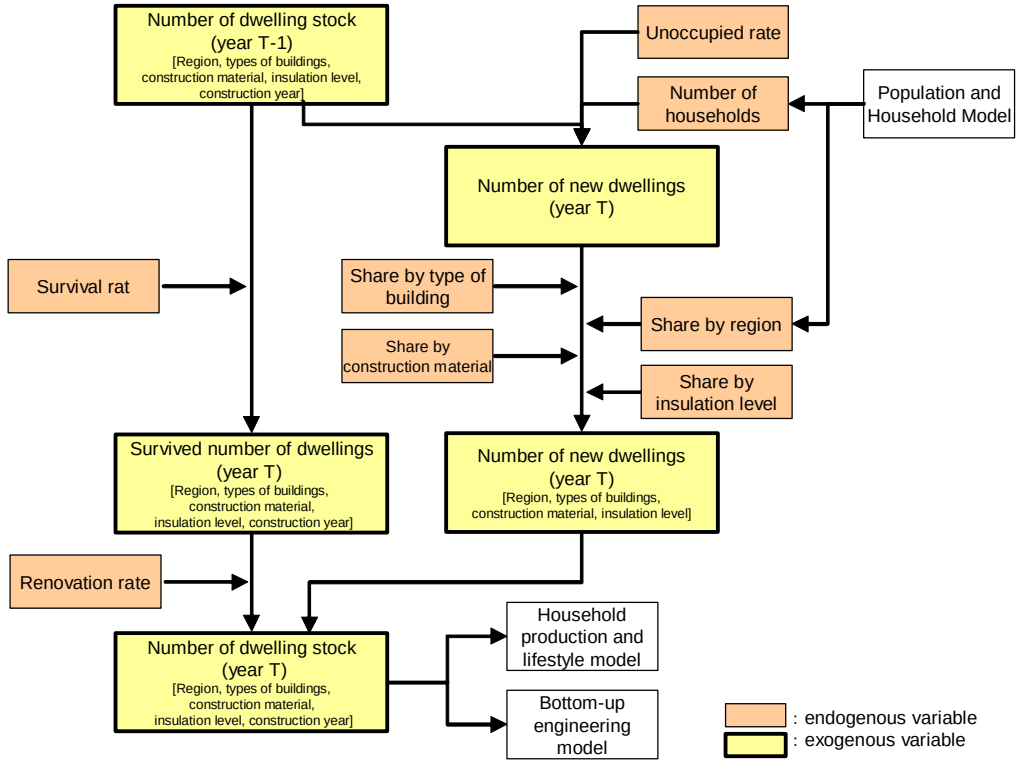
year	2000	2050	
		A	B
Population (million)	126.9	94.5	100.3
Urban population(%)	78.1	84.2	76.7
Agricultural area population(%)	8.2	7.1	8.5
Forest area population(%)	13.7	8.7	14.8

Building Dynamics Model

- Enhancement of building insulation is very effective countermeasures. 60% of the heating demand from the residential sector can be cut down, if appropriate insulation systems are installed. Besides, configuration of buildings in urban and rural area affects social energy efficiency greatly.

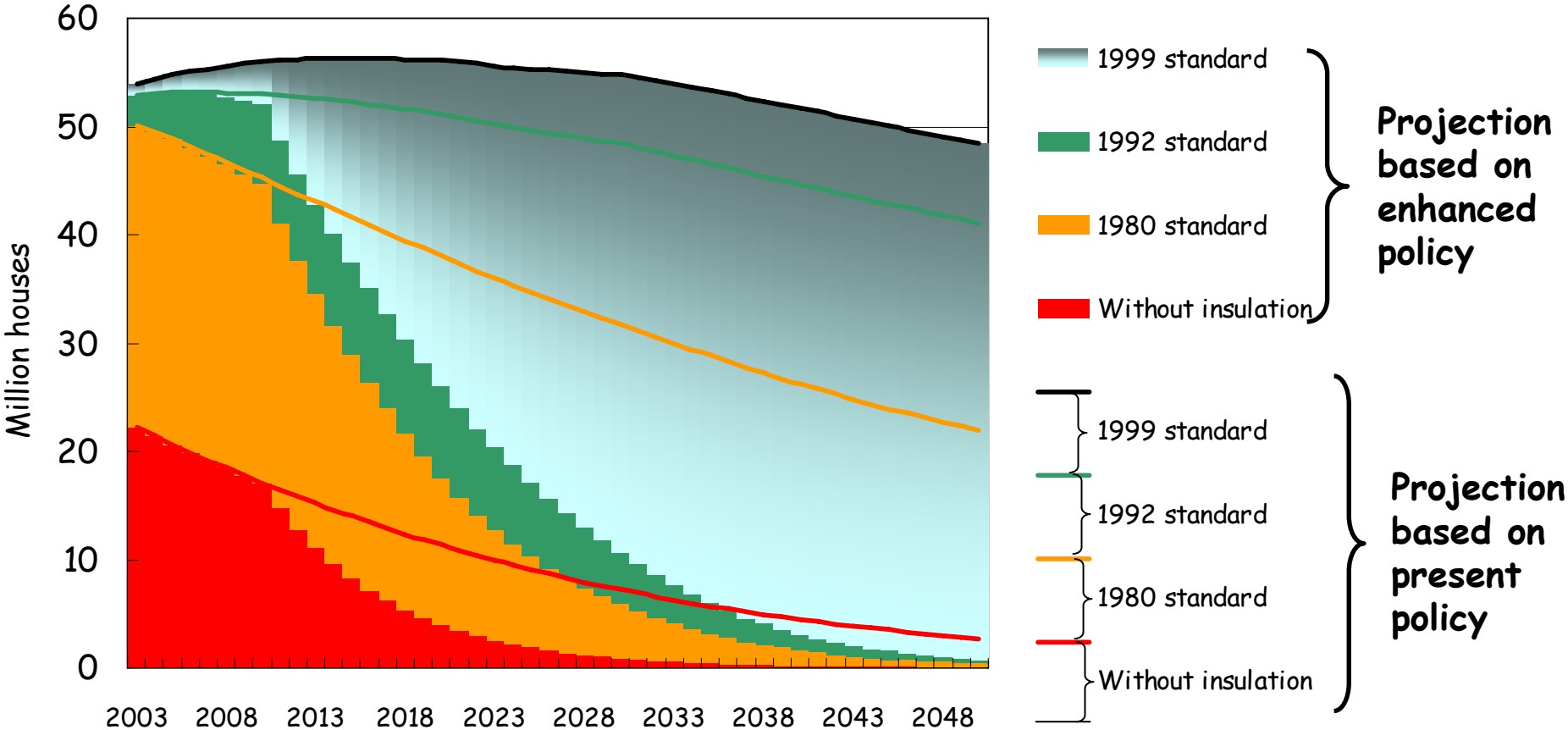
- In order to take account these factors, a model of building dynamics (BDM) was developed.

- 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.



Flowchart of BDM (residential)

Projection of residential building stock by insulation level

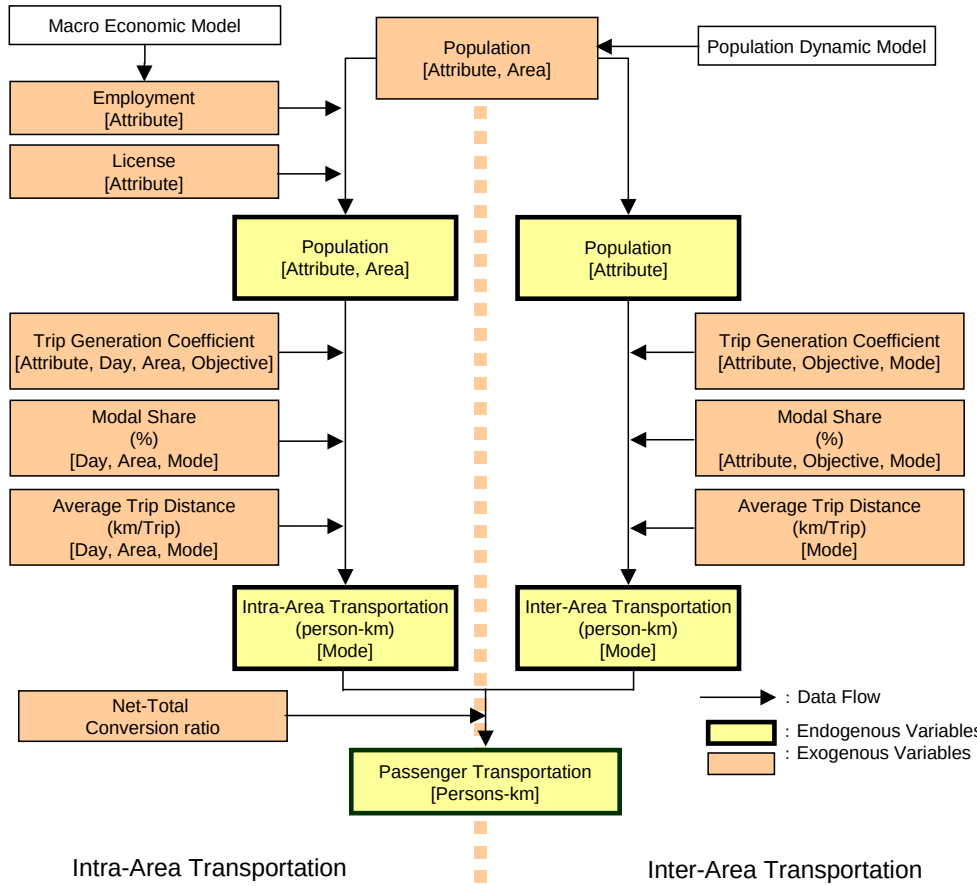


Passenger Transportation Demand Model

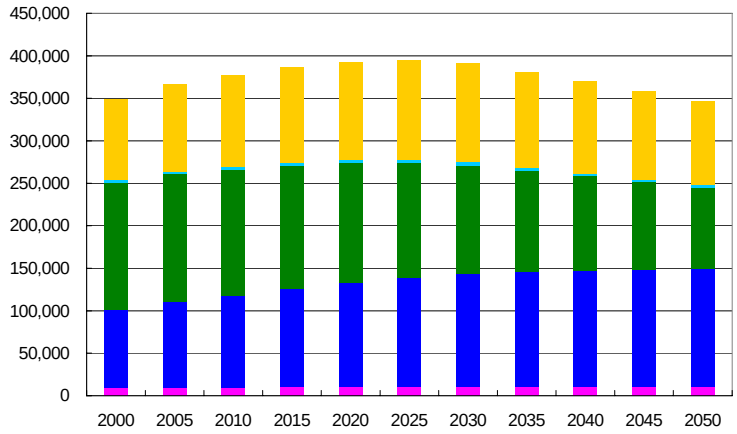
- Many effective countermeasures exist related with transportation. Modal shift from private motor vehicles to mass transit systems, urban planning towards compact cities, transportation substitution with diffusions of teleworking and virtual communication systems and so on.
- Passenger Transportation Demand Model (PTDM) can simulate transportation demand associated with changes in population distribution, people's activity patterns, modal shares and average trip distances.
- The 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,

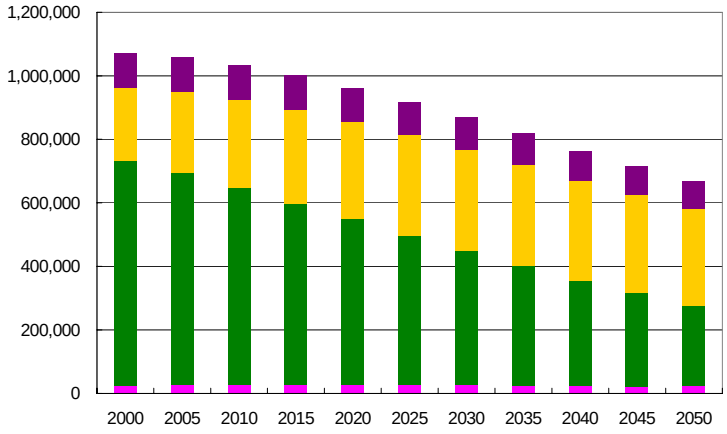
  and they are calculated separately.



Passenger Transportation Demand Model (2)
Scenario A



Inter-region transportation demand by mode of transportation (mil. person-km)



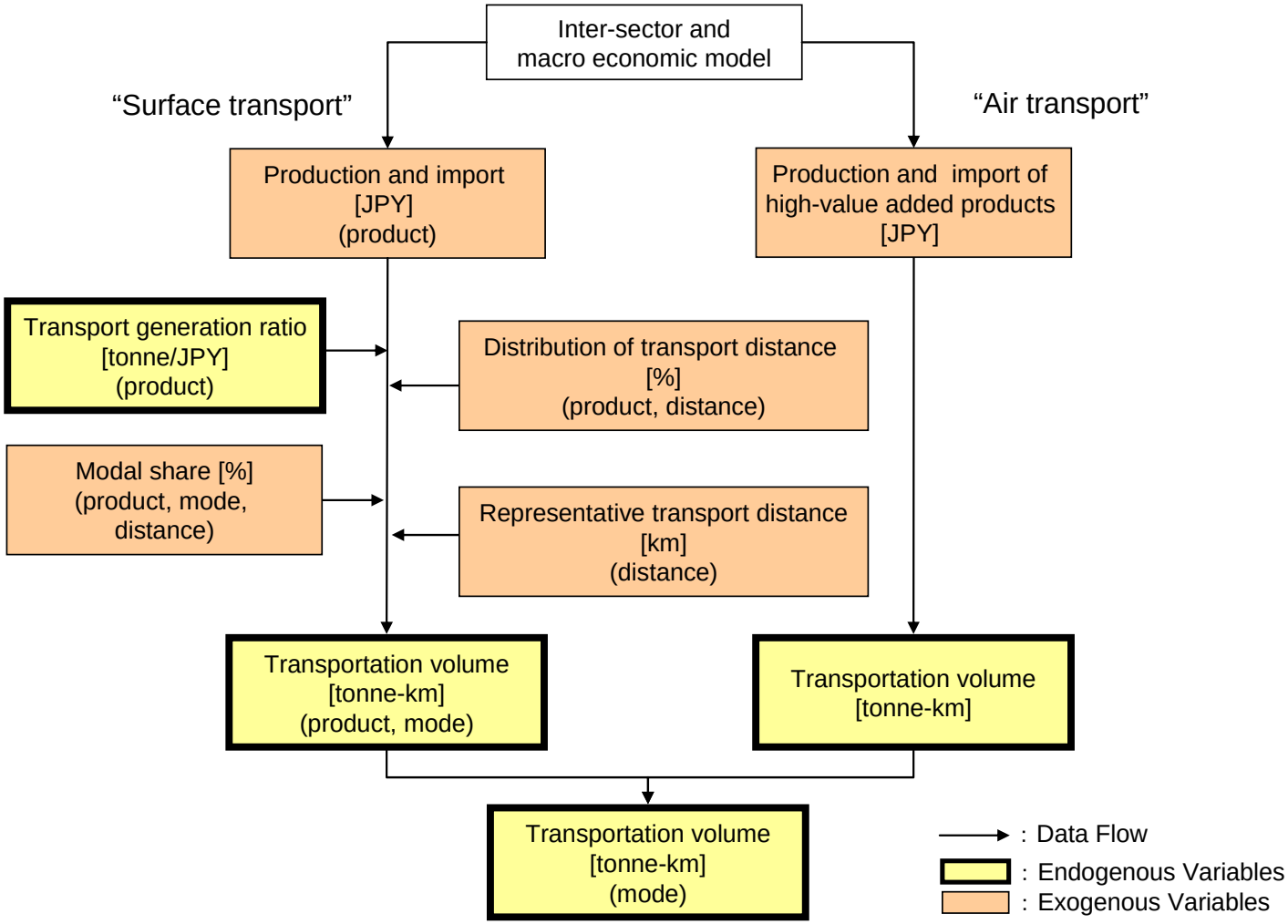
Intra-region transportation demand by mode of transportation (mil. person-km)

Buses Aviation Pass.cars Maritime Railways Walk&Bike

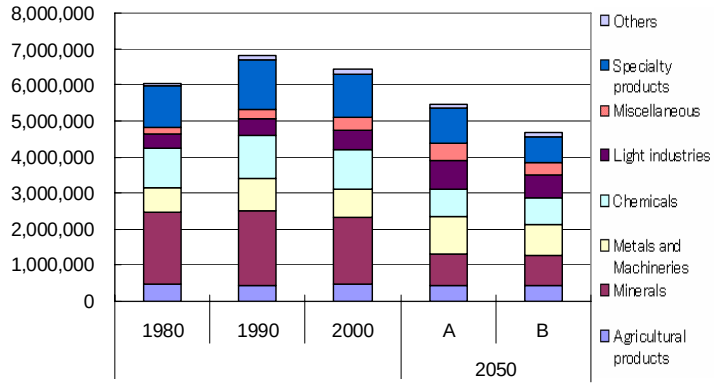
- Coupled with population decrease, and intensive decreasing policy of average trip distance, such as the compaction of neighborhood communities causes significant decrease of intra-regional transportation demand.
- In addition, the share of railways transportation will increase rapidly due to the promotion of modal shift from car to train.

Freight Transportation Demand Model

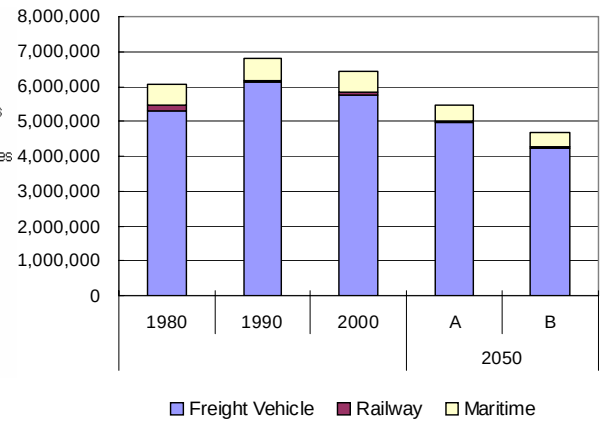
This model simulates freight transportation volume associated with changes in industrial structure, material density of commodities, transportation distance, and modal share.



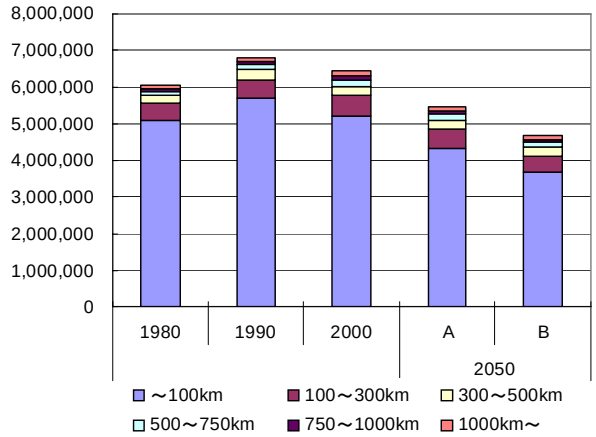
Freight Transportation Demand Model (2)



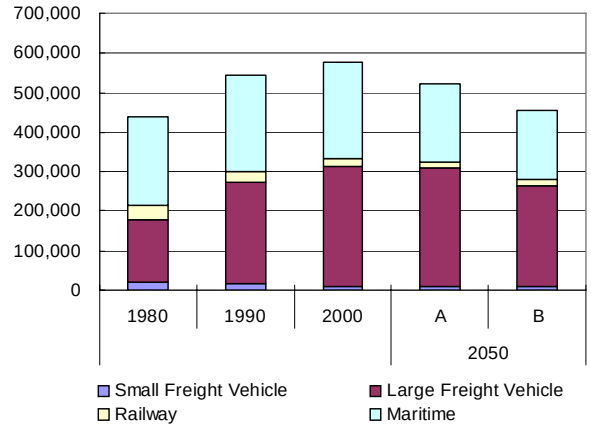
Transportation volume in tonnes by product (1000 tonne)



Transportation volume in tonnes by mode (1000 tonne)



Transportion volume in tonnes by transport distance (1000 tonne)

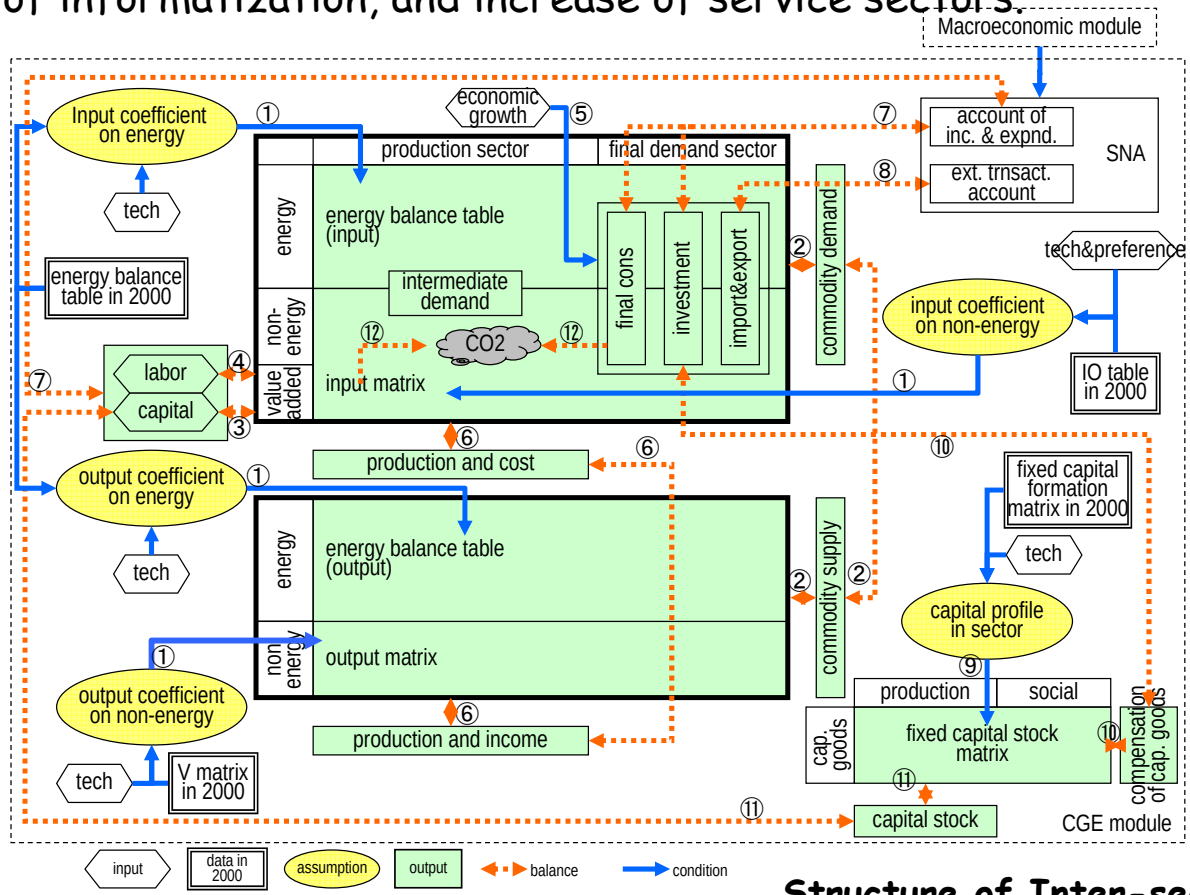


Transportion volume in tonne-km by mode (mil. tonne-km)

- By year 2050, in tonne-km, the volumes of freight transport are 0.91 and 0.79 times, because of the decrease of long-distance transport of basic materials.
- On the contrary. short distance transport does not decrease so much.

Inter-sector and Macro Economic Model

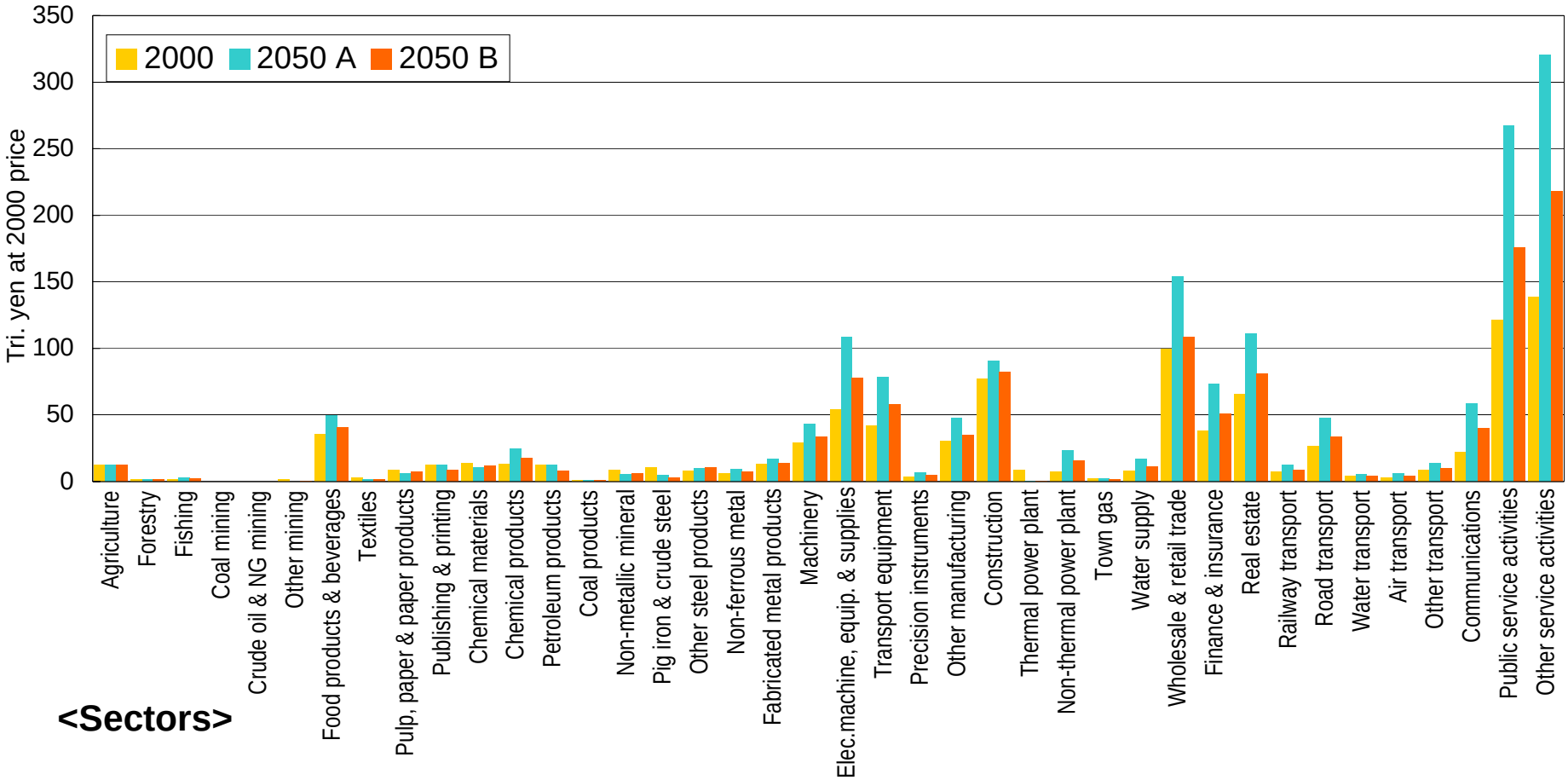
- Projecting macro economic activity, sectoral production, and also taking account the countermeasures proposed in the individual models, we developed "Inter-sector and Macro Economic Model (IMEM)", which consists of a sequential dynamic general equilibrium module and a macroeconomic module.
- The model can be used to estimate national and sectoral economic activities, the impacts of energy efficient and dematerialization technologies in industrial sectors, development of informatization, and increase of service sectors.



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

Structure of Inter-sector Module

Examples of the projected sector productions in year 2050

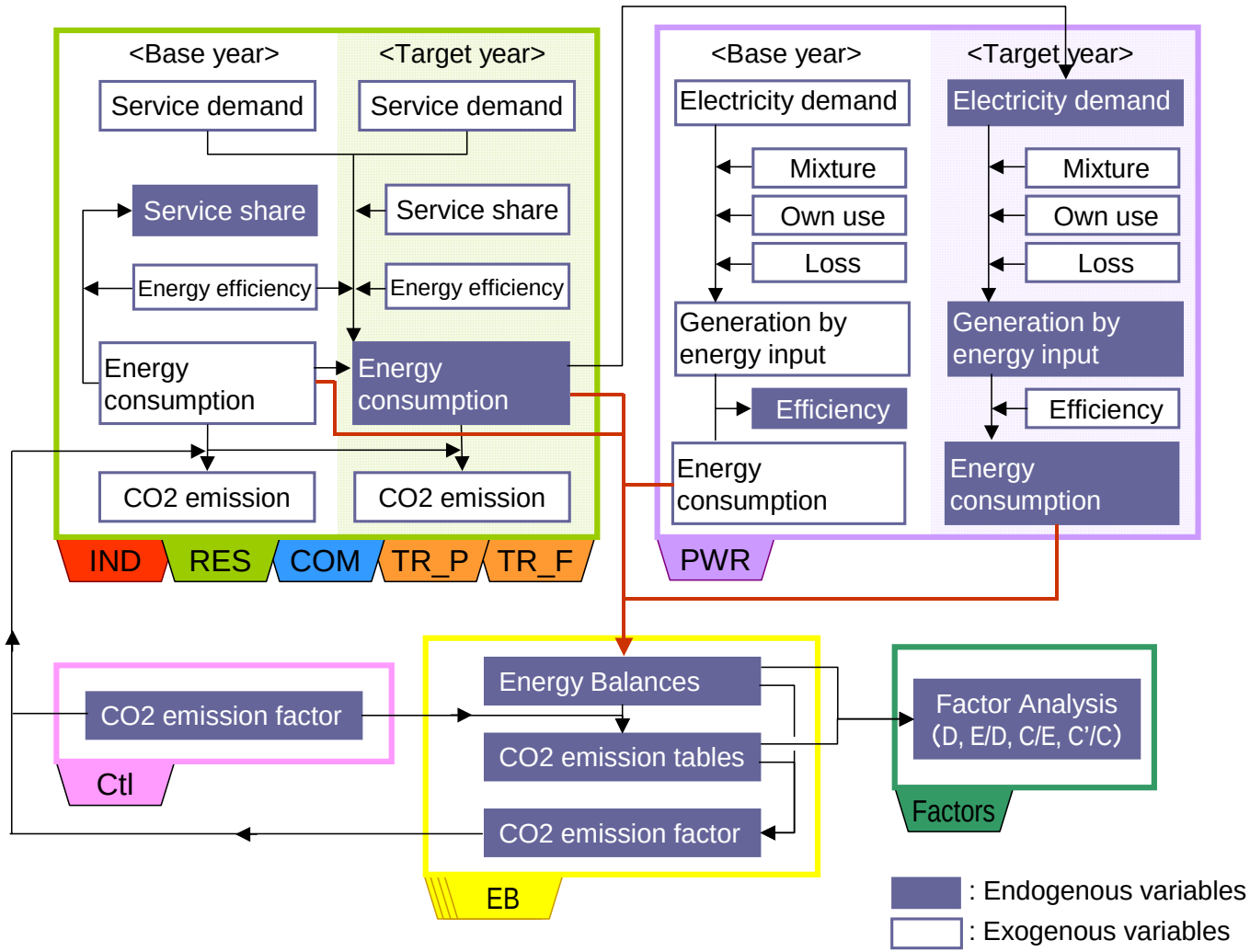


Integration tools for quantitative, transparent discussion toward a LCS

- Snapshot Integration Tool (SSI)
  - ·Reconciliation of the outputs of element models and technology development
  - ·Calculation of energy balance table, CO2 emission table, as well as various national social and economic accounts
  - ·Excel/GAMS based.

- Backcasting Model for transient control (BCM)
  - ·Combining the equations and parameters in the element models, and formulating the problem with an inter-temporal multi-sector optimum problem
  - ·Control variables: schedules of investment, necessary technology development etc.
  - ·With the model, required cost to reach the target world, trade-off between the today's effort, feasibility and the future burdens to attain target societies
  - ·GAMS based.

Snapshot Integration Tool (SSI)
- energy part -



Quantification of Scenario A and B in 2050

year	unit	2000	2050 A		2050 B		model
Population	Mil.	127	94	(74%)	100	(79%)	
Household	Mil.	47	43	(92%)	42	(90%)	Population and Household model
Average number of person per household		2.7	2.2		2.4		
GDP	Tril.JPY	538	1059	(197%)	693	(129%)	
Share of production							Inter-sector and Macro Economic Model
primary	%	1.8%	1.0%		1.4%		
secondary	%	39.9%	32.3%		35.4%		
tertiary	%	58.4%	66.7%		63.3%		
Office floor space	Mil.m^2	1654	2078	(126%)	1739	(105%)	Building dynamics Model & Inter-sector and Macro Economic Model
Travel Passenger volume	bill. p·km	1297	1016	(78%)	794	(61%)	
Private car	%	53%	27%		53%		Transportation demand model & Inter-sector and Macro Economic Model
Public transport	%	40%	62%		34%		
Walk/bycycle	%	8%	8%		13%		
Freight transport volume	bill. t·km	578	525	(91%)	458	(79%)	
Industrial production index		100	142	(142%)	113	(113%)	
Steel production	Mil.t	107	40	(37%)	40	(37%)	Inter-sector and Macro Economic Model
Etylen production	Mil.t	8	4	(50%)	4	(50%)	
Cement production	Mil.t	82	40	(49%)	40	(49%)	
Paper production	Mil.t	32	16	(50%)	27	(85%)	

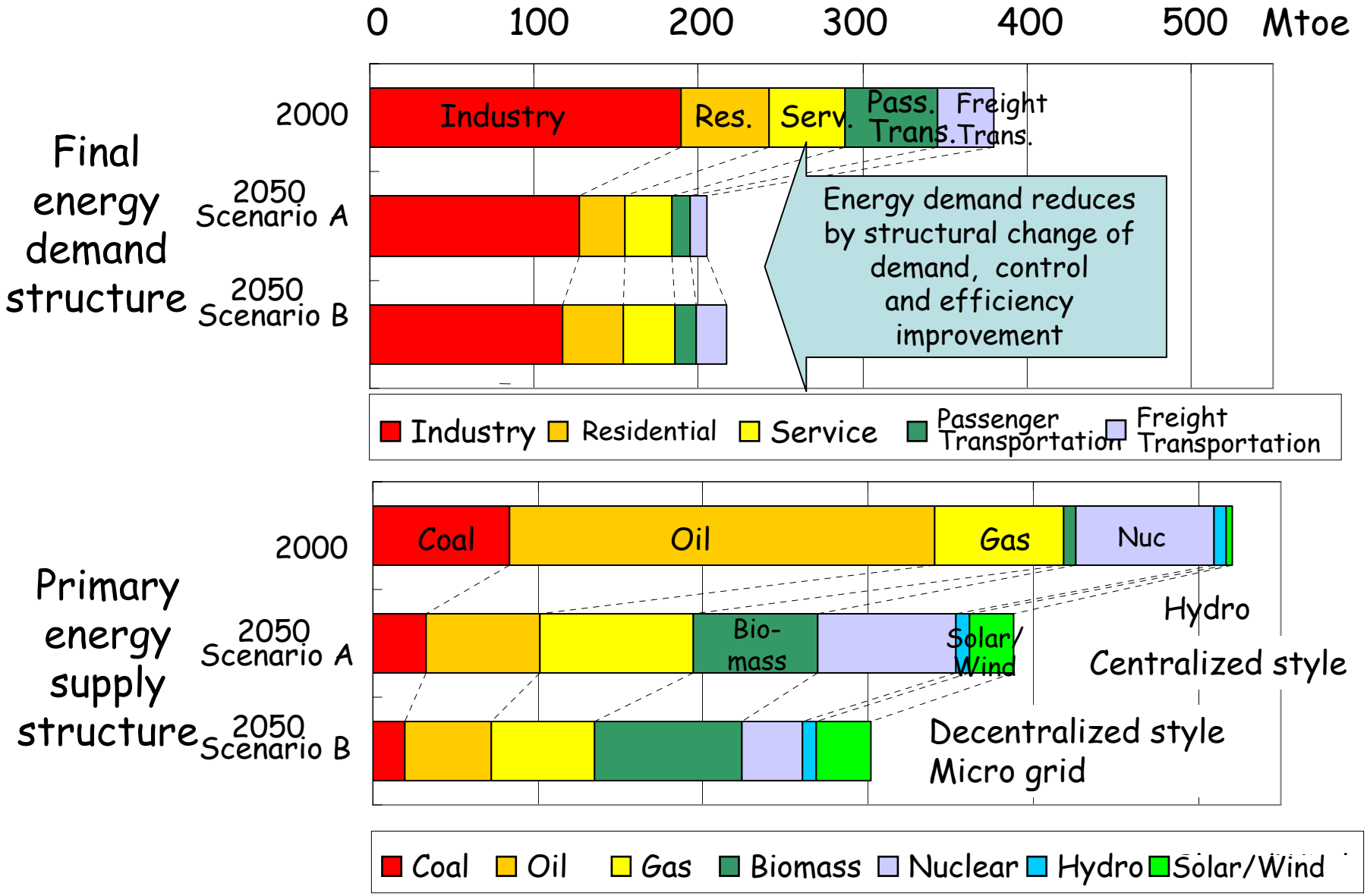
(%) is a percentage compared with year 2000

Energy and CO_2 emission in 2050

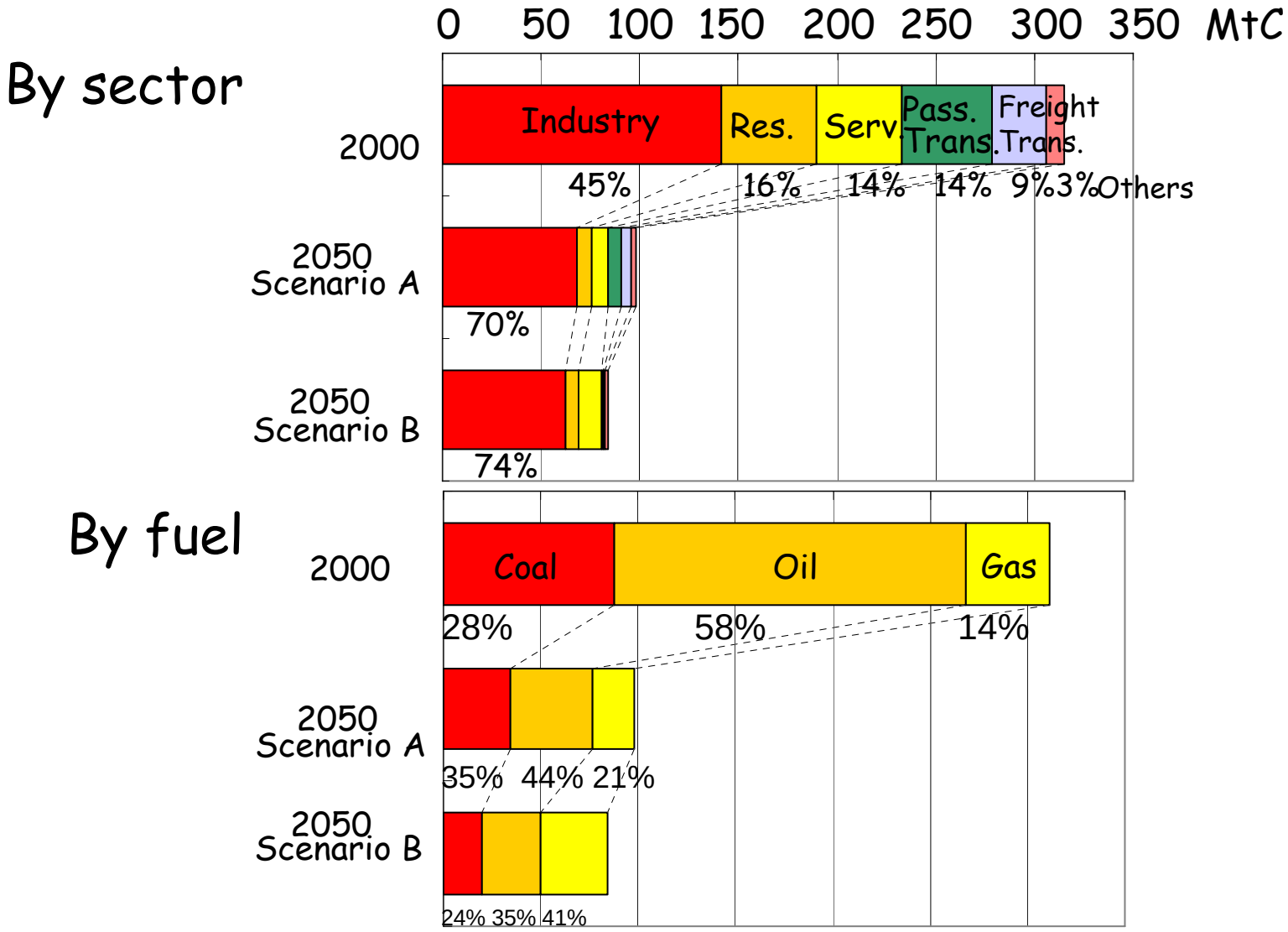
year		1990	2000	2050 Scenario A		2050 Scenario B	
CO_2(MtC)	Emission	284.0	311.5	97.7	(34%)	84.3	(30%)
	CCS			-30.0			
	Generation	284.0	311.5	127.7	(45%)	84.3	(30%)
Energy (MTOE)	Primary	446.0	520.7	388.3	(87%)	301.7	(68%)
	Final	292.0	380.2	205.5	(70%)	217.0	(74%)
	Fossil fuel dependency		80.4%	49.9%		44.6%	
GDP (tril.JPY)		467.9	537.5	1058.9	(226%)	693.4	(148%)
Population (Mill.)		123.6	126.9	94.4	(76%)	100.3	(81%)

(%) is a ratio with 1990

Projected energy structures



Projected CO_2 emission structure

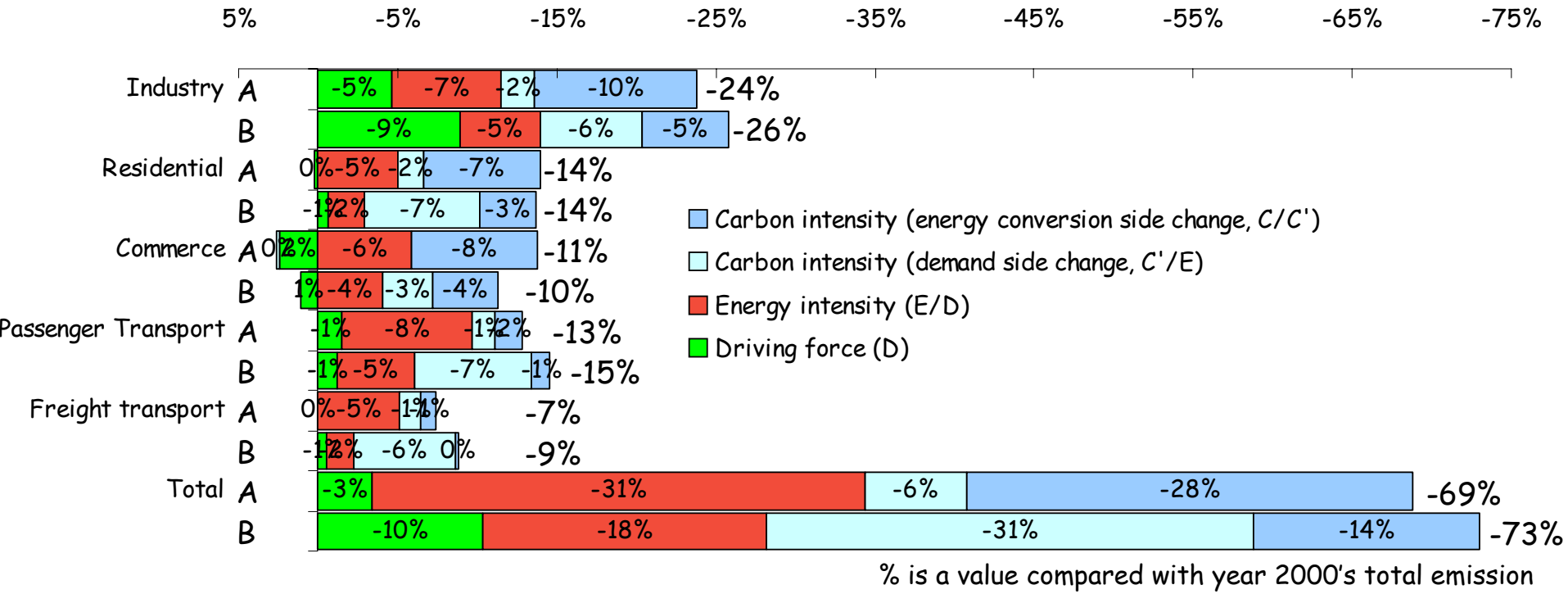


Factor decomposition of CO_2 emission reduction in 2050

$$C = D \times \frac{E}{D} \times \frac{C'}{E} \times \frac{C}{C'}$$

$$\frac{\Delta C}{C} = \frac{\Delta D}{D} + \frac{\Delta(E/D)}{(E/D)} + \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta(C/C')}{(C/C')}$$

C: CO_2 emissions
D: Activity
E: Energy demand
C': CO_2 emissions (excluding energy conversion sector)



% is a value compared with year 2000's total emission

Possible trend-breaking options to achieve 70% reductions toward 2050 in Japan (Scenario A)

	Main driving forces to reduce CO2 emissions	Category	amount*
Society	・Reduce raw material production ・Decrease number of population	Activity	23MtC
Industry	・Production efficiency improvement	EE	27MtC
	・Increase of natural gas use	CI	
Residential	・Use of high insulation system ・Control of home energy system	SD	16MtC
	・High efficiency air-conditioner, hot water heater, lighting system ・Fuel cell system, Photovoltaics on the roof	EE	8MtC 21MtC
		CI	11MtC 9MtC
Transport-ation	・Replacement of working/living place ・Public transportation	SD	30MtC
	・Motor-driven mobiles: Electric Battery Vehicles, Fuel Cell Battery Vehicles	EE	11MtC
		CI	
Energy supply	・Nuclear energy ・Use of electricity in night time, Electric storage ・CO_2-free hydrogen supply	CI	41MtC
	・Advanced fire plant + CCS ・Hydrogen supply using fossil fuel + CCS	CCS	30MtC

amount	
Service Demand (SD) 40	Demand side
Energy Efficiency (EE) 78	
Carbon Intensity (CI) 79	Supply side
CCS 30	

* CO_2 reduction amount compared with the emissions in 2000

CCS: Carbon Capture Storage

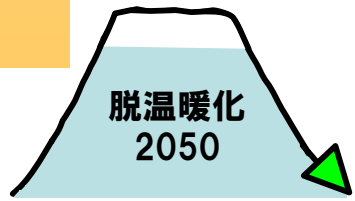
Concluding my presentation…

What we are now doing;

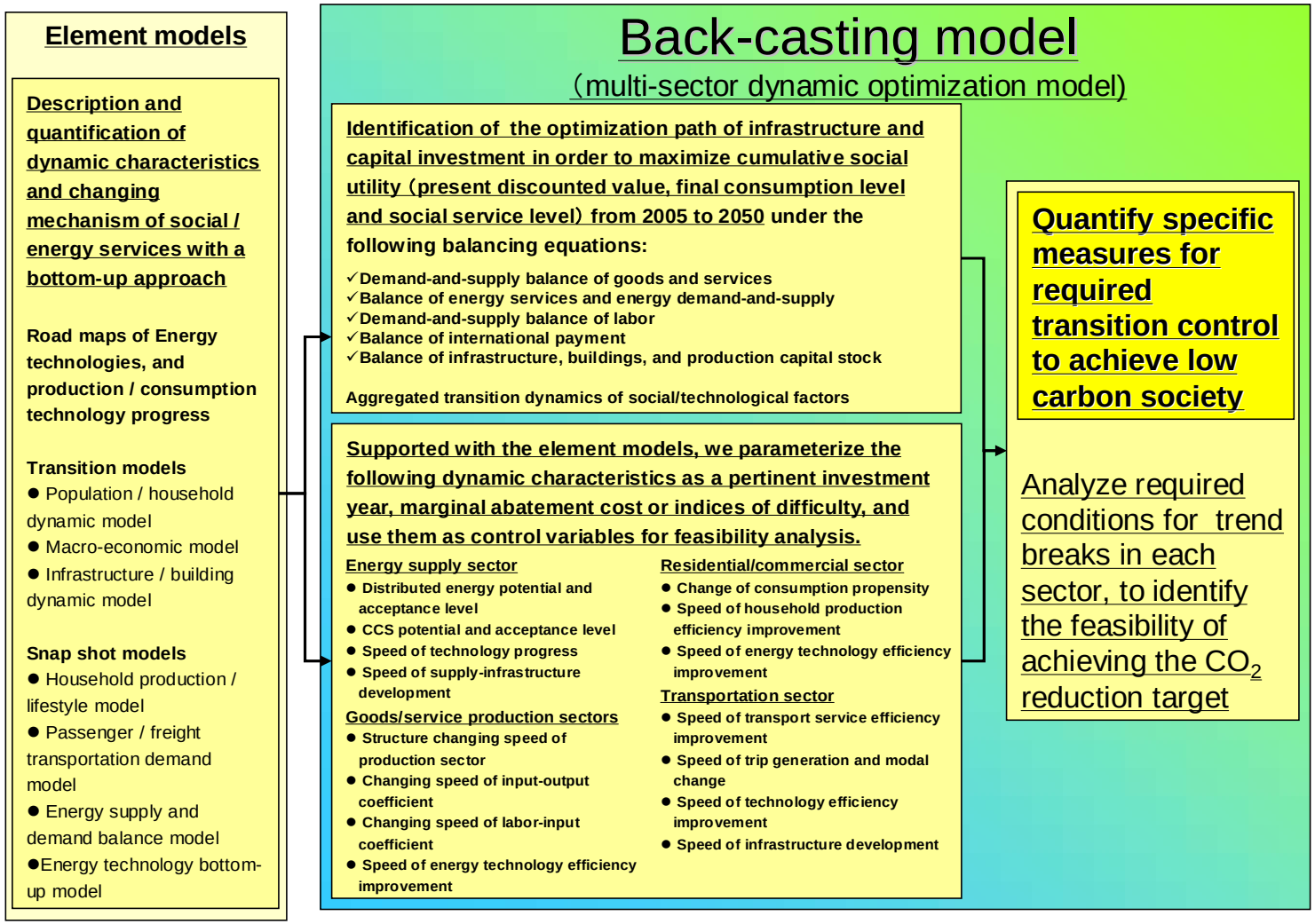
1. Describing Japan's social and economic structure in 2050
2. Identifying CO_2 emission reduction measures and quantifying their effects in order to realize 60-80% reduction, which are consistent with the future visions,

And plan to do soon are;

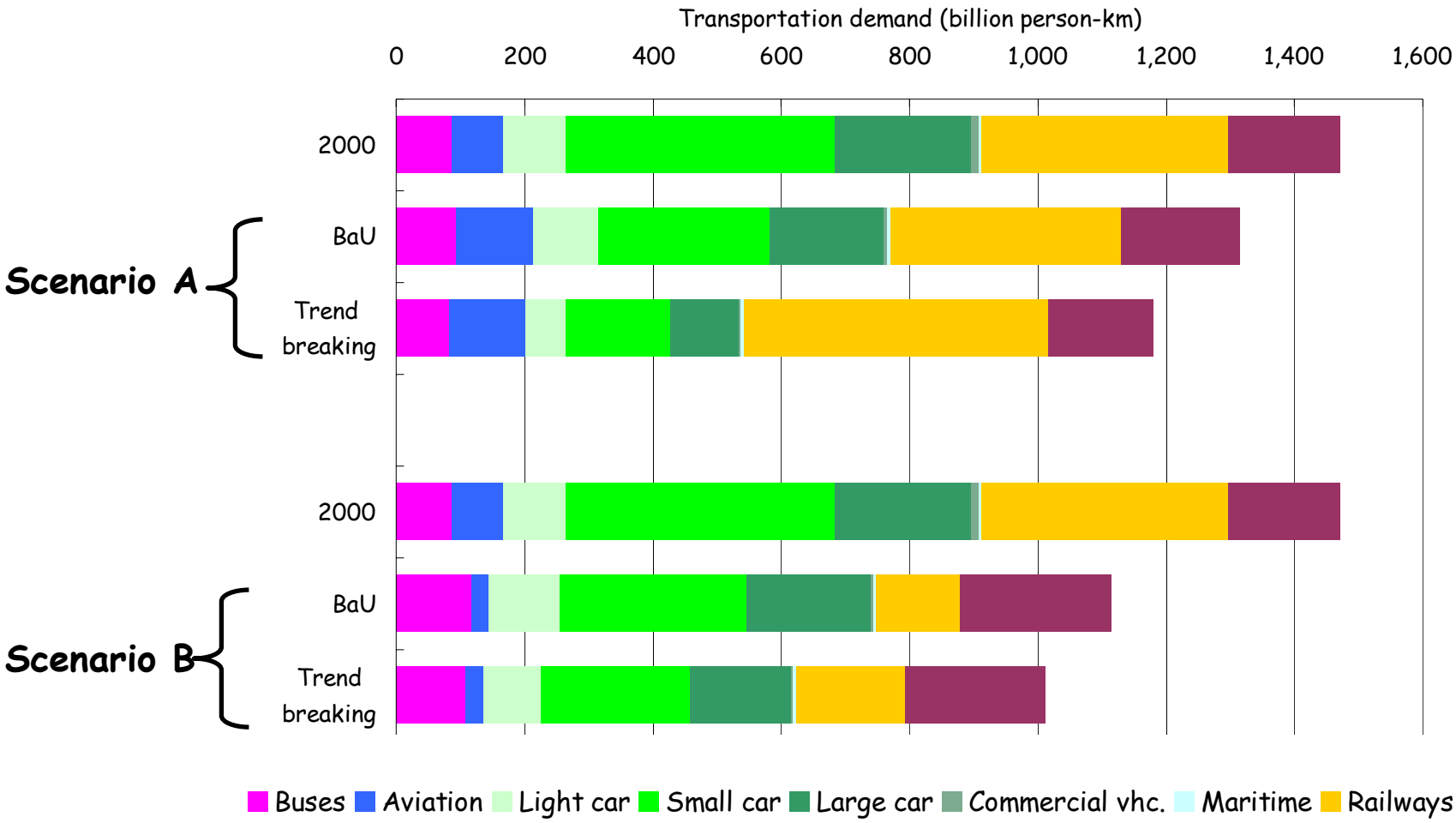
1. Establishing Japan's roadmaps toward LCS, including social, economical and technological innovation strategy,
2. Capacity building and supporting activity for Asian countries on developing individual countries' own roadmaps toward LCS



Backcasting model (BCM) for Japan low carbon society project



Passenger transport demand reduction by scenario



Two types of models were required to support scenario development

(1) Snapshot model

The first group focuses on describing LCS in a certain future (e.g. year 2050), concretely, quantitatively, and consistently with physical, economical, technological laws.
We call the models, "Snapshot models". Examples are;

- Household Production and Lifestyle model
- Passenger and Freight transportation demand model
- Energy supply and demand balance model
- Energy technology bottom-up model
- Inter-sector model
- Simplified snapshot model

Two types of models were required to support scenario development

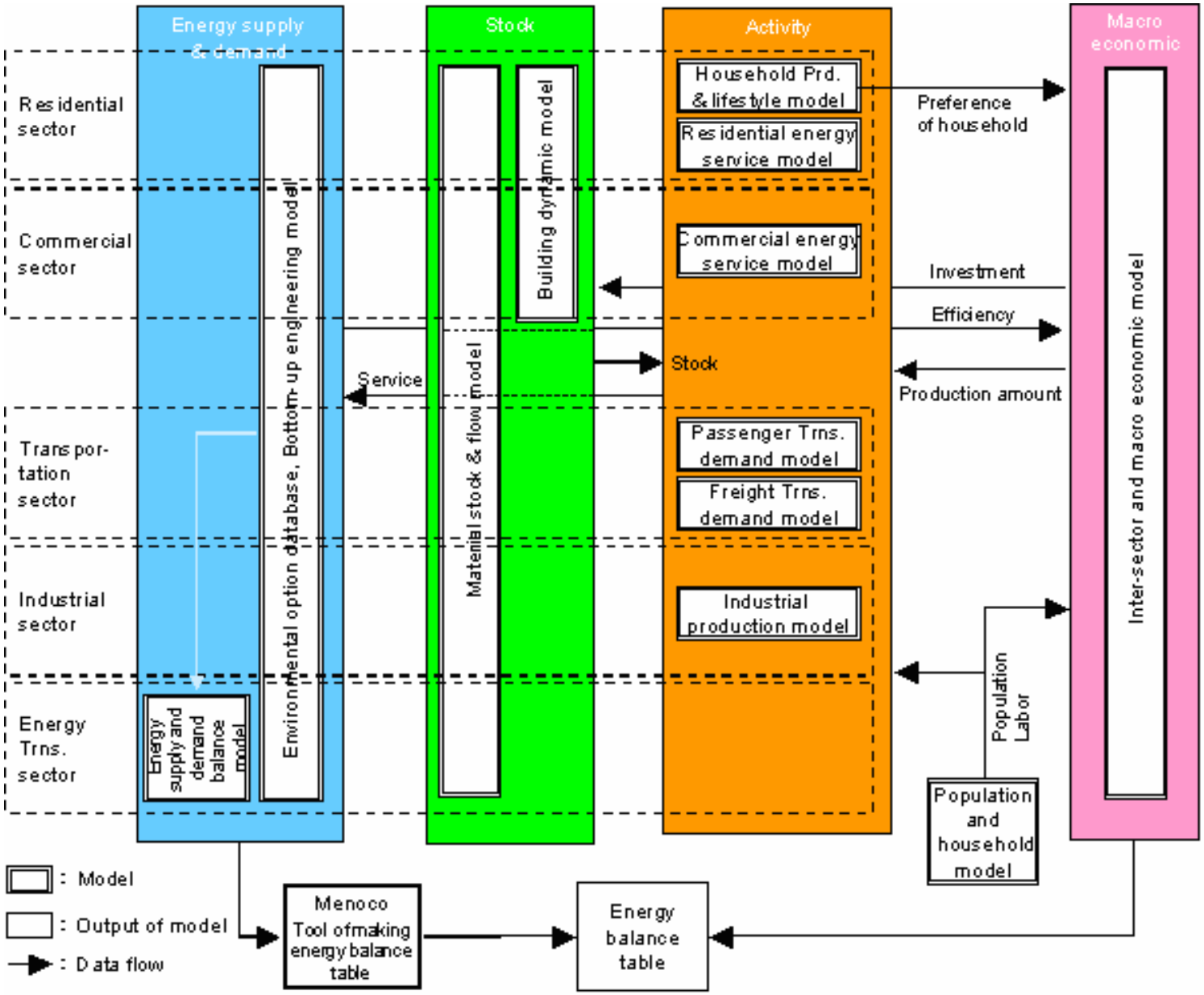
(2) Transition model

The second group focuses on the dynamics and trend transition of the society, economic system, and the technological system. We call models of the group, "Transition models". Examples are;

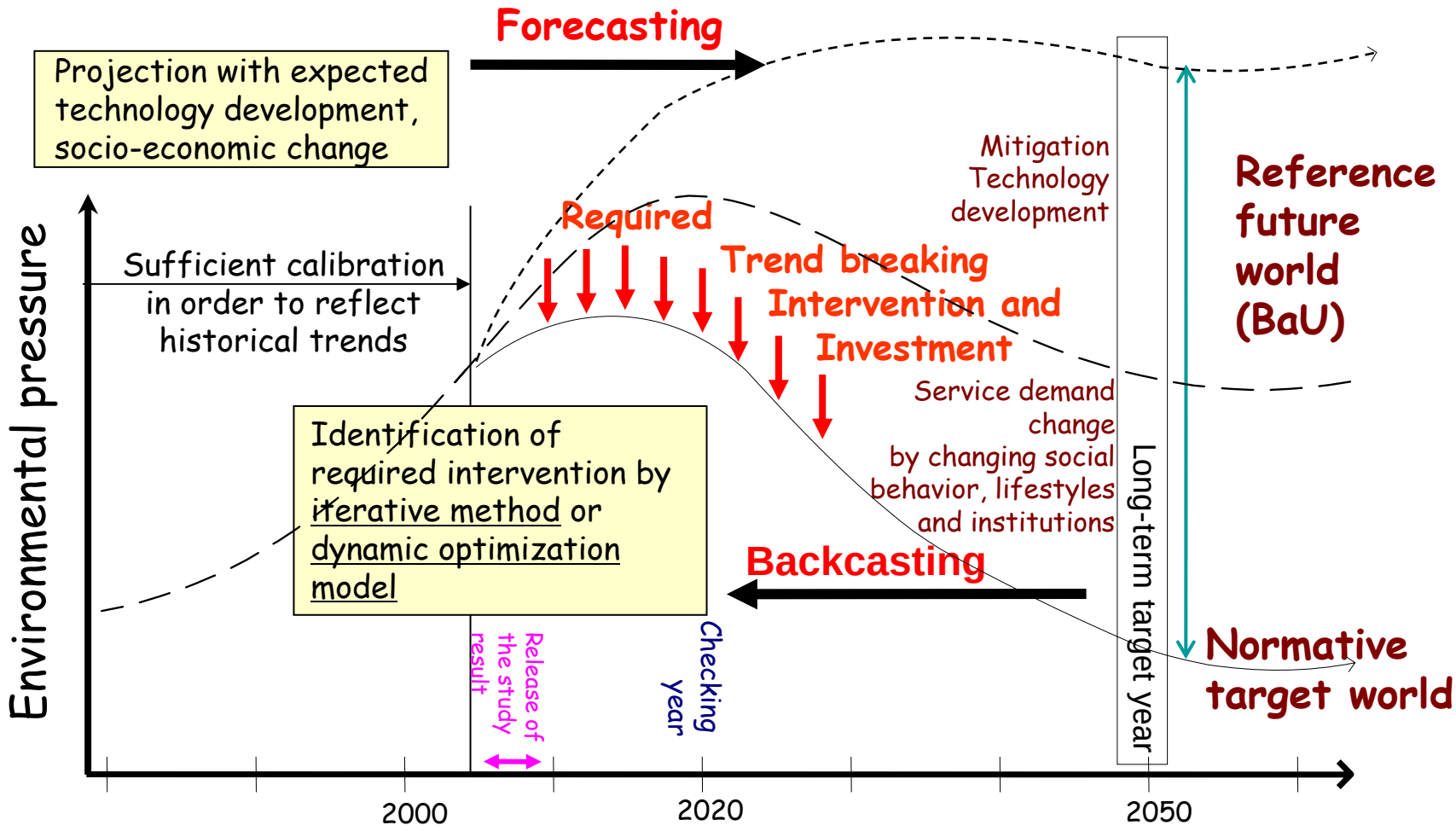
- Population and household transition model
- Material Stock and Flow model
- Building Dynamics model
- Macro Economic model

We link the "Snapshot models" and the "Transition models" to construct future LCS visions, and to identify/evaluate required interventions for realizing LCS.

Relationship among element models



Forecasting from now and Backcasting from future prescribed/normative world



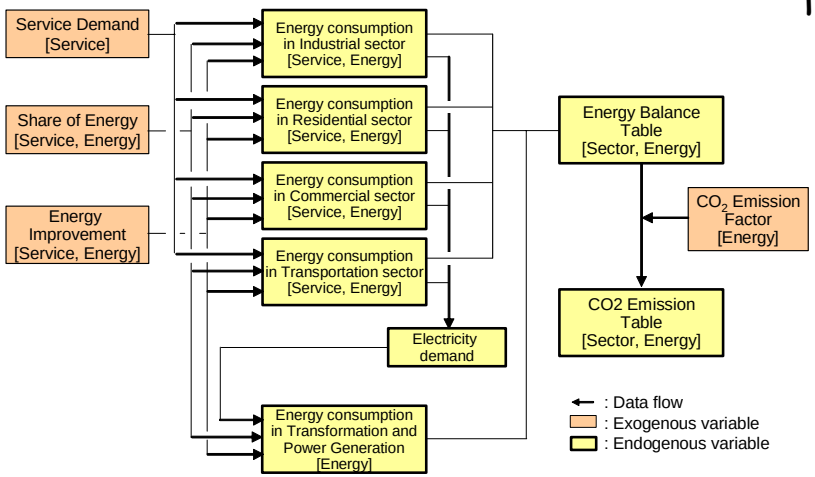
Besides these models, we prepared

Menoco Tool

- "Menoco" means "back of the envelope" type calculation in Japanese. It was developed on MS Excel, and calculates an energy balance table, a CO_2 emission table It is suitable for communication among stakeholders to design LCS.

Environmental Options Database (EDB)

- A database system which stores information of related activities.
- Activity includes energy technology, institution, infrastructure, lifestyle, and other aspects, and narrative description and quantitative value are entered in the database.
- An engineering bottom-up type energy and emission calculator is attached to this database.
- The EDB serves as an exchange platform between the each sectors experts and the scenario team.



Flowchart of the "Menoco"

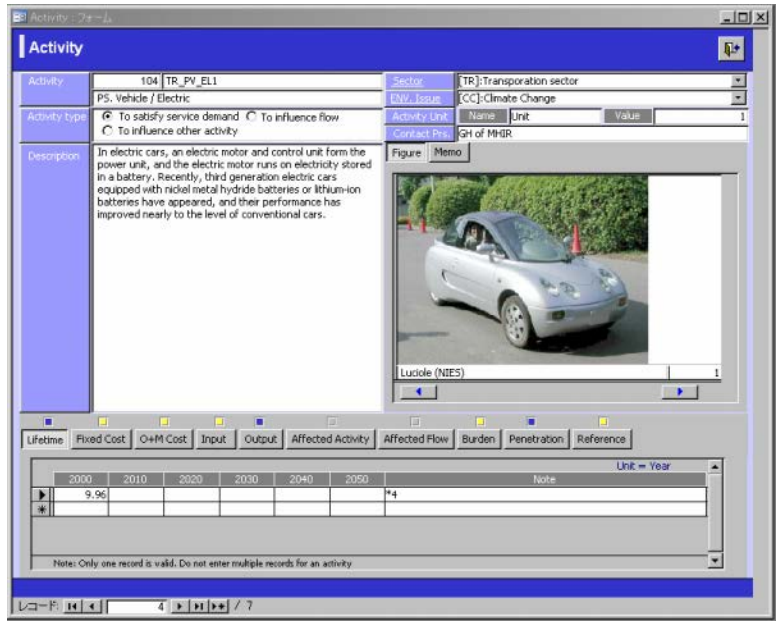
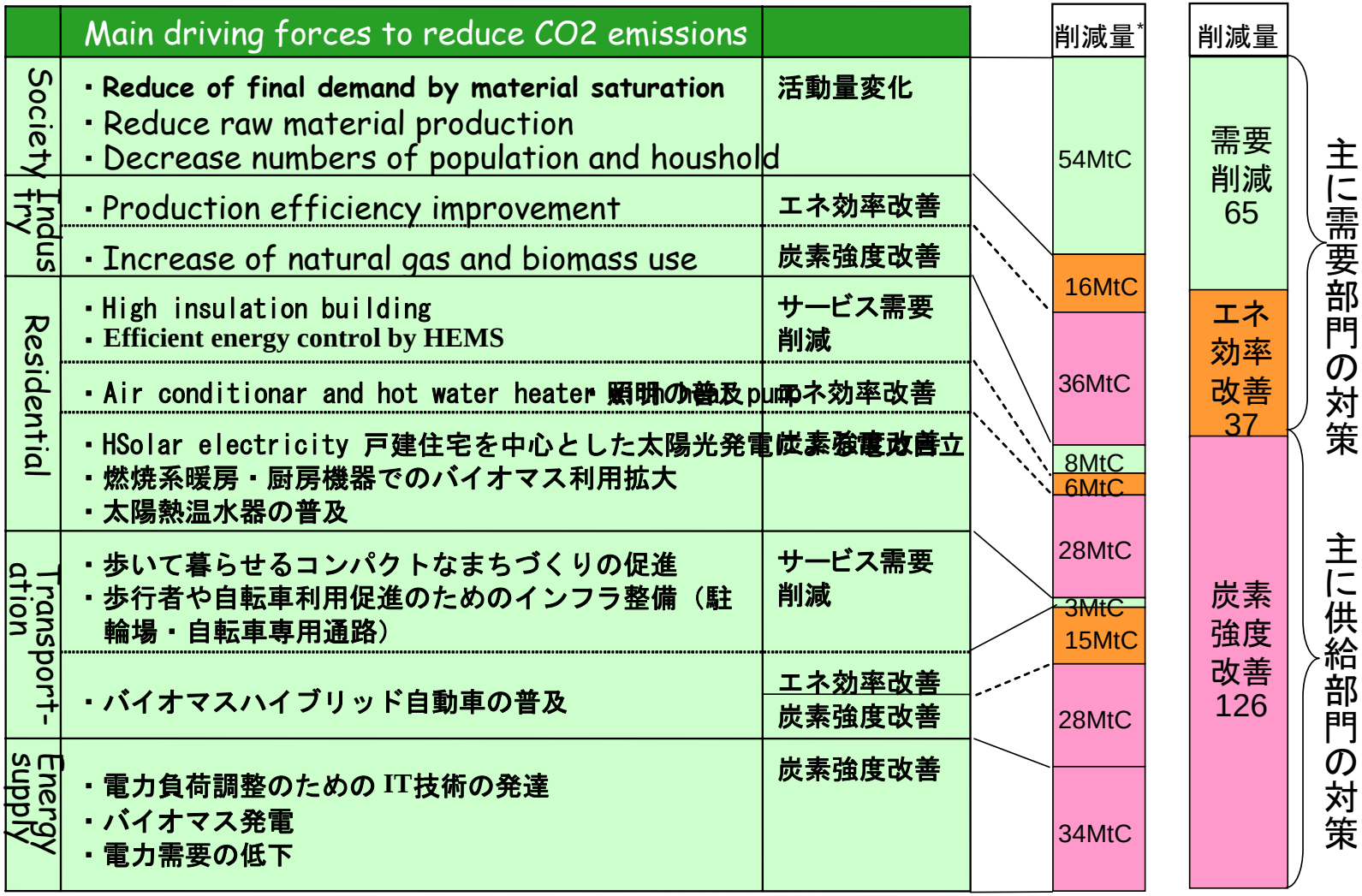


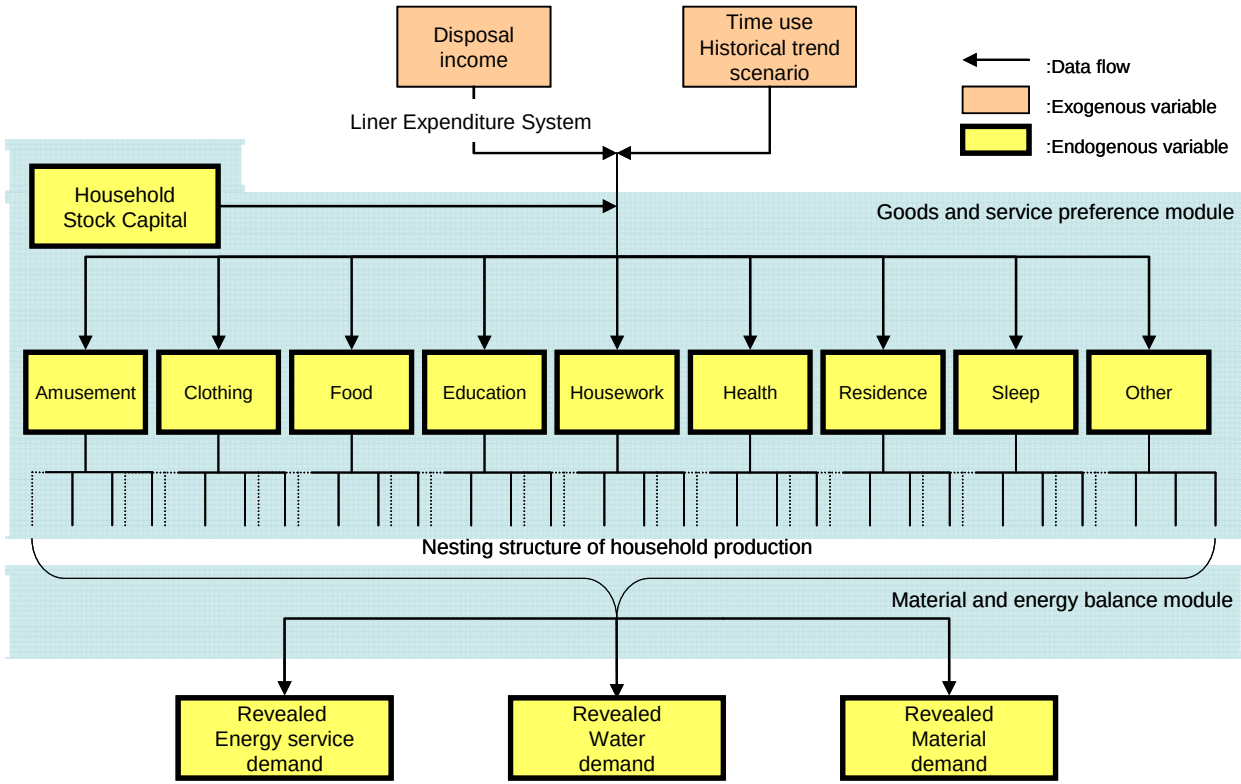
図9．70%削減を実現する対策オプションの検討[シナリオ B:2050年]



* CO2削減量は2000年における排出量からの削減量を示している。

Household Production and Lifestyle Model

- CO_2 emissions from the residential sector have been increasing with the growing number of households and people's lifestyle changes. The trend is expected to continue with the spreading use of ICT appliances and housekeeping robots.
- People's preference of goods and service, the efficiency improvements of household production are greatly affects the realization of the LCS.
- The Household Production and Lifestyle Model(HPLM) simulates energy service demand, waste generation, and water consumption for household production by four household types, under prescribed scenarios of household type composition, age composition, income budget, and time budget in the future.

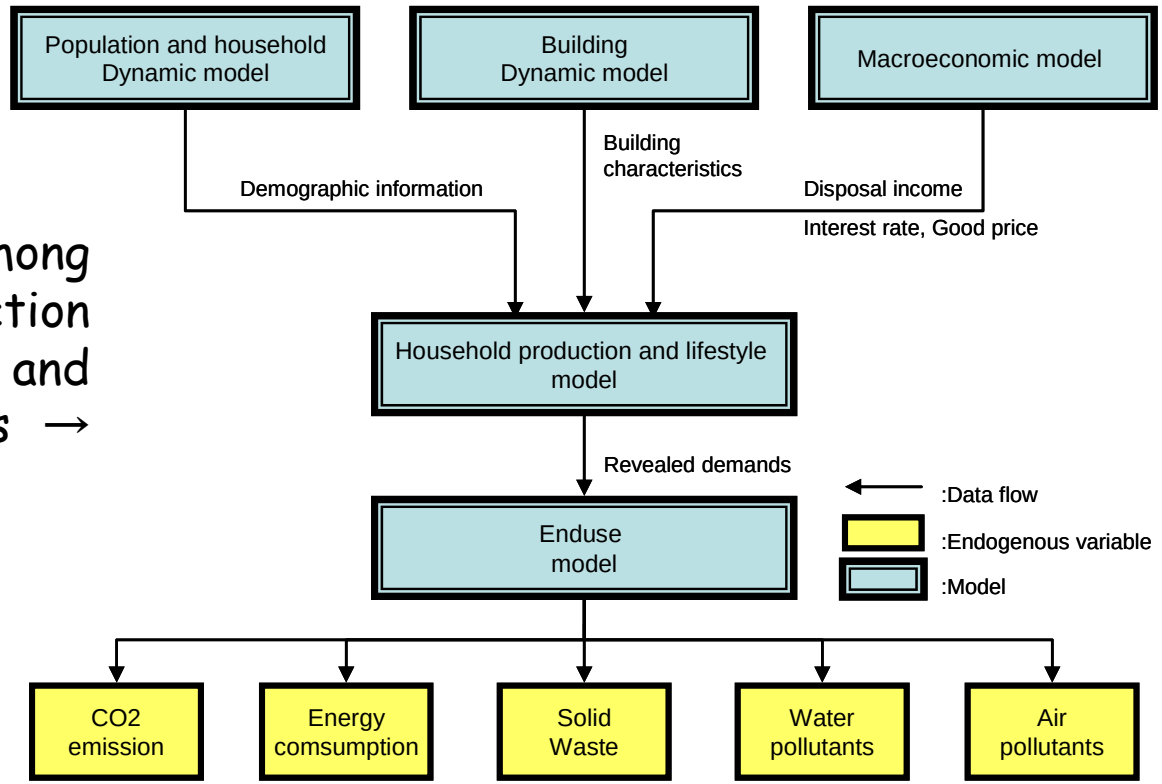


Flowchart of HPLM

Household Production and Lifestyle Model(2)

- The model can consider demographic and socioeconomic trends with consistency, together with Population and Household Dynamics Model, Building Dynamics Model, and Inter-sector and Macro Economic Model.

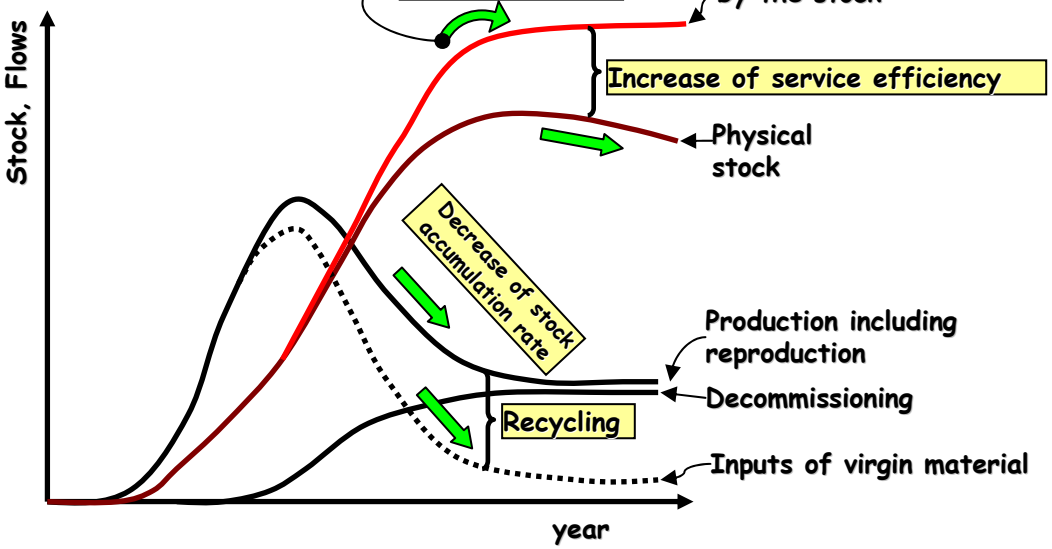
Linking among Household production and lifestyle model and related models →



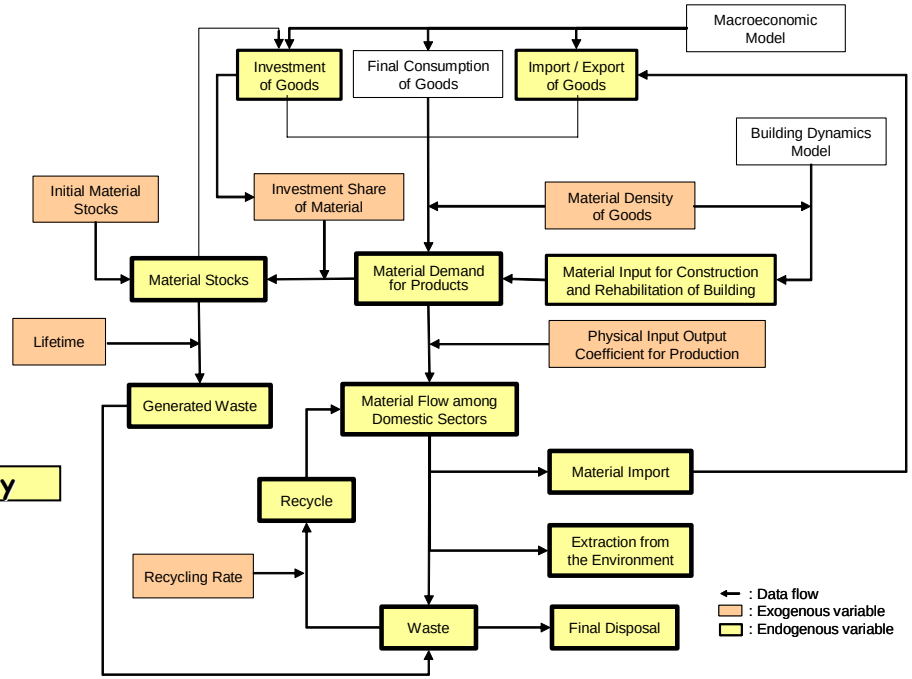
Material Stock and Flow Model

Material Stock and Flow Model (MSFM) estimates the change of material stocks and flow in the society. Factors considered in the model are final consumption and investments which are affected by capital stocks, material densities of goods, physical input output coefficients of production sectors, and recycling rate of wastes.

Stock dynamics greatly affects social energy/material efficiency



These factors affect energy consumption, greatly

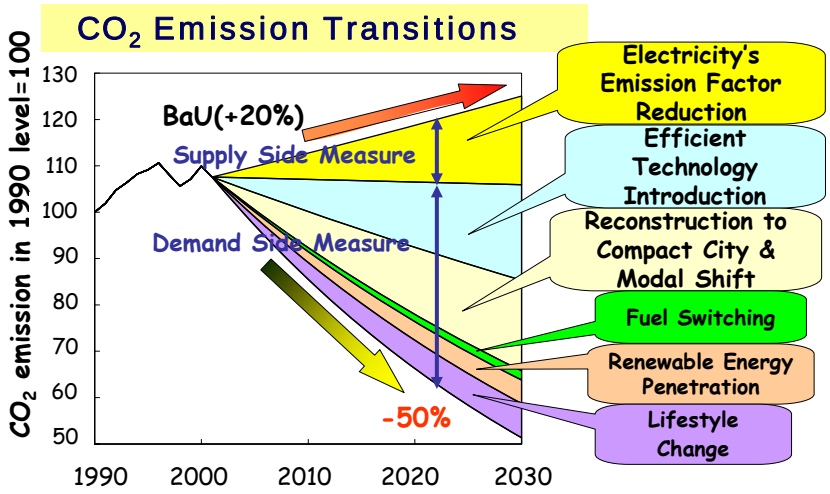


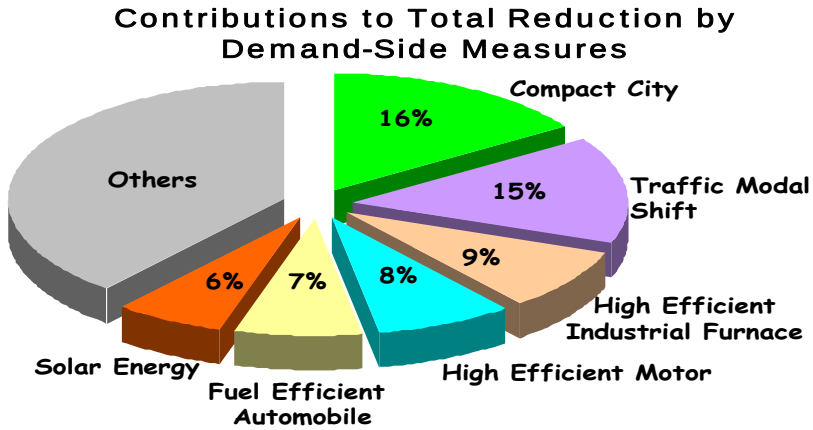
Flowchart of MSFM

Application to local society -A Case Study in Shiga, Japan-

Shiga Prefecture (area: 4017km^2, population: 1.37 million) is at the center of Japan. It has the largest lake in Japan, Lake Biwa, and is surrounded by mountains clad in fresh greenery, and has many fertile plains.

People in Shiga have been very conscious about protecting their rich environment, and now, the Shiga government is start to design their long-term plan towards a Low Carbon Society. The models in this presentation were used to project quantitative aspects of the planning.





Key concepts of two scenarios

Keywords		Scenario A	Scenario B
Mindset of people			
	Goal of life	· Social success	· Social contribution
	Residence	· Urban orientation	· Rural orientation
	Family	· Self-dependent	· Cohabitation
	Acceptance of Advanced technology	· Positive	· Prudent
Population			
	Birth rate	· Downslide	· Recover
	Immigration of foreign workers	· Positively accepted	· Status quo
	Emigration	· Increase	· Status quo
Landuse and cities			
	Migration	· Centralization in large cities	· Decentralisation
	Urban area	· Concentration in city centre · Intensive land use in urban area	· Population decrease · Maintain minimum city function
	Countryside	· Significant population decrease · Advent of new businesses for efficient use of land space	· Gradual population decrease · Local town development by local communities & citizens

Key concepts of two scenarios (2)

Keywords		Scenario A	Scenario B
Life and household			
	Work	- Increase in "Professionals" - High-income & over-worked	- Work sharing - Working time reduction & equalization.
	Housework	- Housekeeping robots & Services	- Cooperation with family & neighbours
	Free time	- Paid - for activity - Improving carrier - Skill development	- With family - Hobby - Social activity (i.e Volunteer activity)
	Housing	- Multi-dwellings	- Detached houses
	Consumption	- Rapid replacement cycle of commodities	- Long lifetime cycle of commodities (Mottainai)
Economy			
	Growth rate	- Per capita GDP growth rate:2%	- Per capita GDP growth rate:1%
	Technological Development	- High	- Not as high as scenario A
Industry			
	Market	- Deregulation	- Adequate regulated rules apply
	Primary Industry	- Declining GDP share - Dependent on import products	- Recovery of GDP share - Revival of public interest in agriculture and forestry
	Secondary Industry	- Increasing add value - Shifting production sites to overseas	- Declining GDP share - High-mix low-volume production with local brand
	Tertiary industry	- Increase in GDP share - Improvement of productivity	- Gradual increase in GDP share - Penetration of social activity

Modeled production sectors and commodities in the inter-sector module

Activities	
Primary industry	Agriculture / Forestry / Fishing
Mining	Coal mining / Crude oil and natural gas mining / Other mining
Manufacturing	Food products and beverages / Textiles / Pulp, paper and paper products / Publishing and printing / Chemical materials / Chemical products / Petroleum products / Coal products / Non-metallic mineral products / Pig iron and crude steel / Other steel products / Non-ferrous metal / Fabricated metal products / Machinery / Electrical machinery, equipment and supplies / Transport equipment / Precision instruments / Other manufacturing
Construction	
Power plant	Nuclear power plant / Thermal power plant / Hydro power plant / Geothermal plant / Photovoltaic generation / Wind power plant / Waste power plant / Biomass power plant
Town gas	
Water supply	
Service	Wholesale and retail trade / Finance and insurance / Real estate / Public service activities / Other service activities
Transport and communications	Railway transport / Road transport / Water transport / Air transport / Other transport / Communications

Commodities	
Primary energy	Coal / Crude oil / Natural gas / Nuclear / Hydro / Geothermal / Photovoltaic / Wind / Waste / Biomass
Secondary energy	Coaks / Other coal products / Gasoline / Naphtha / Jet fuel / Kerosene / Light oil / Heavy oil / LPG / Other petrorium products / Town gas / Electricity / Hydrogen / Heat
Primary industry	Agriculture / Forestry / Fishing
Other mining	
manufacturing	Food products and beverages / Textiles / Pulp, paper and paper products / Publishing and printing / Chemical materials / Chemical products / Non-metallic mineral products / Pig iron and crude steel / Other steel products / Non-ferrous metal / Fabricated metal products / Machinery / Electrical machinery ,equipment and supplies / Transport equipment / Precision instruments / Other manufacturing
Construction	
Water supply	
Service	Wholesale and retail trade / Finance and insurance / Real estate / Public service activities / Other service activities
Transport and communications	Railway transport / Road transport / Water transport / Air transport / Other transport / Communications