Japan Low-Carbon Society Scenarios Study

- Feasibility of 70% CO2 emissions reductions towards 2050 -

1. **If we cannot go to LCS,…**
2. **LCS offers higher QOL with less energy demand and lower-carbon energy supply**
3. **LCS needs good design, early action, and innovations**

Junichi Fujino
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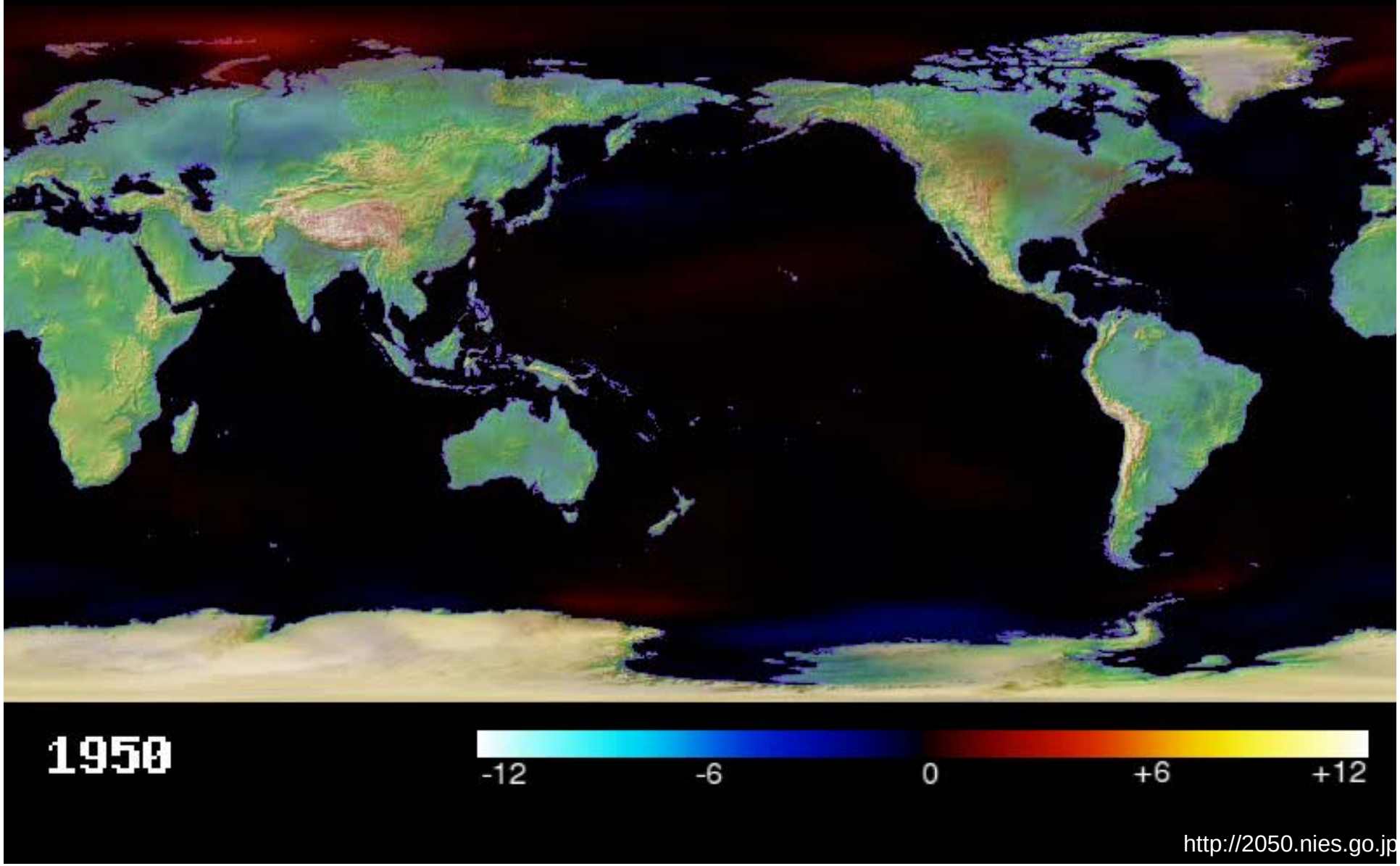
National Institute for Environmental Studies (NIES)

AIM Training Workshop, Tsukuba, Oct 27, 2008

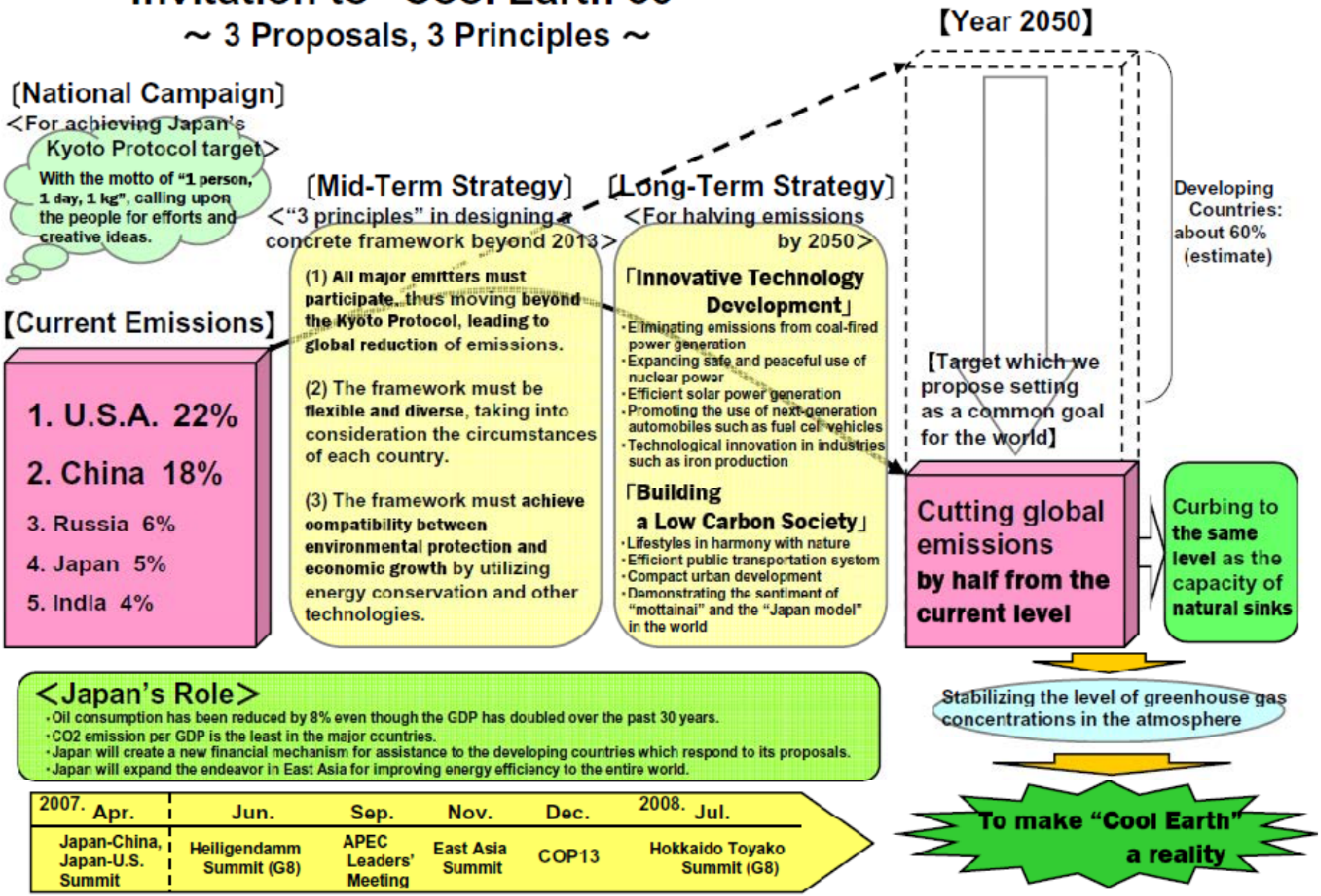
CCSR/NIES/FRCGC, Japan

Surface Air Temperature Change (1900=0 ºC)

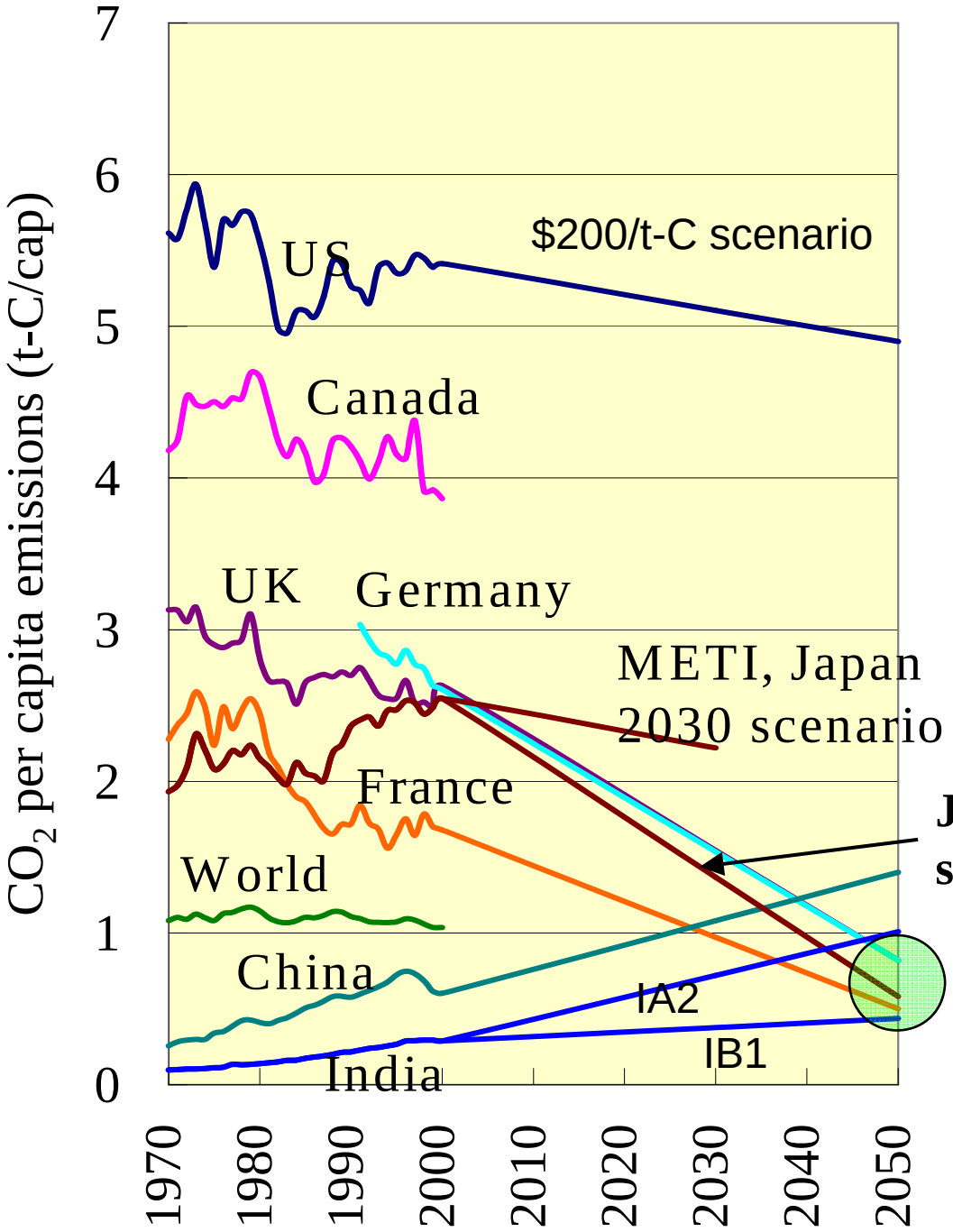


Invitation to "Cool Earth 50"

~ 3 Proposals, 3 Principles ~



http://www.kantei.go.jp/foreign/abespeech/2007/05/24speech_e.html



Current per capita CO_2 emissions and Target

US: delay for tech development, global warming business

EU: Initiatives toward LCS
Japan: Need long-term vision

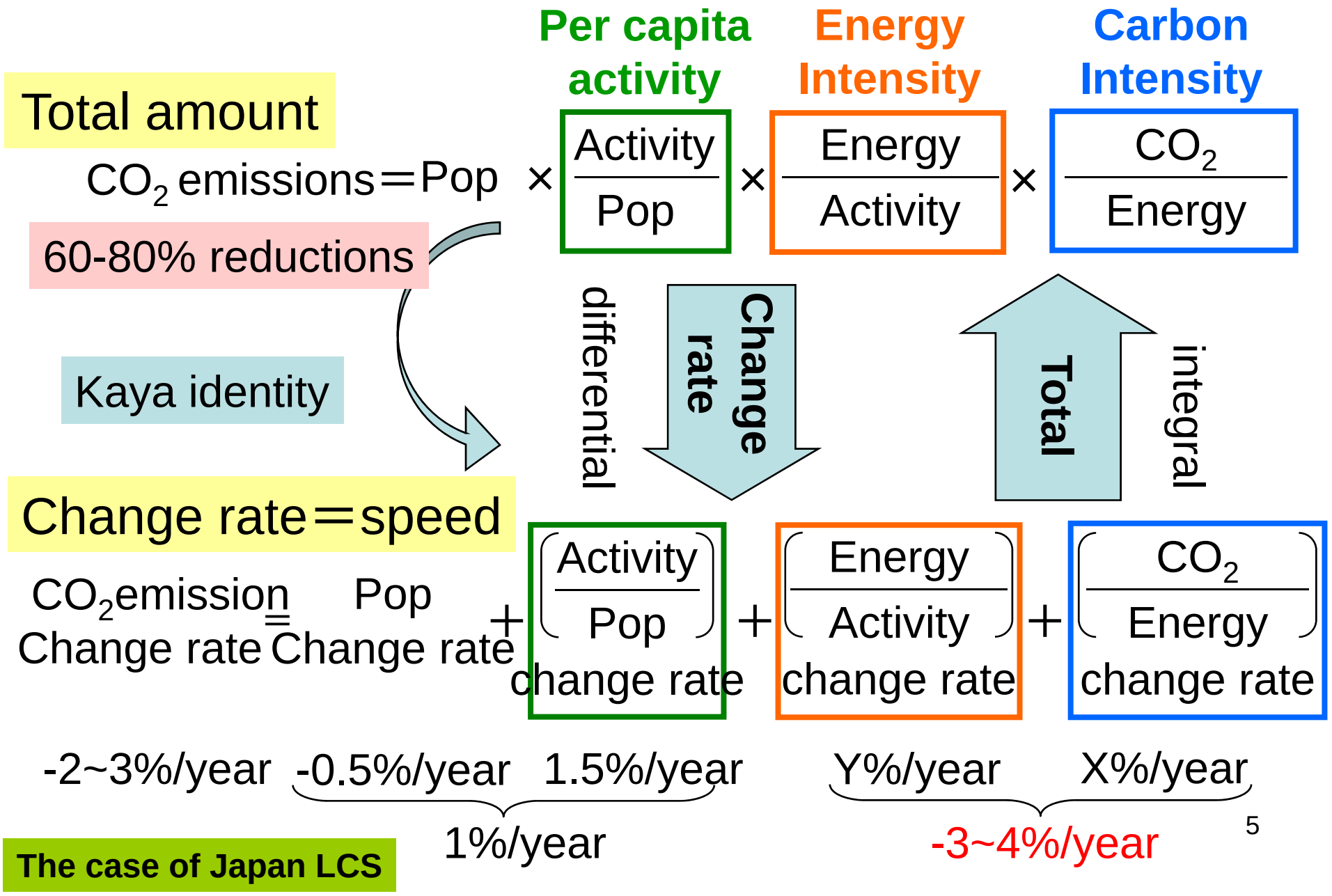
Developing countries: earlier guidance toward LCS is key

Japan 2050 scenario

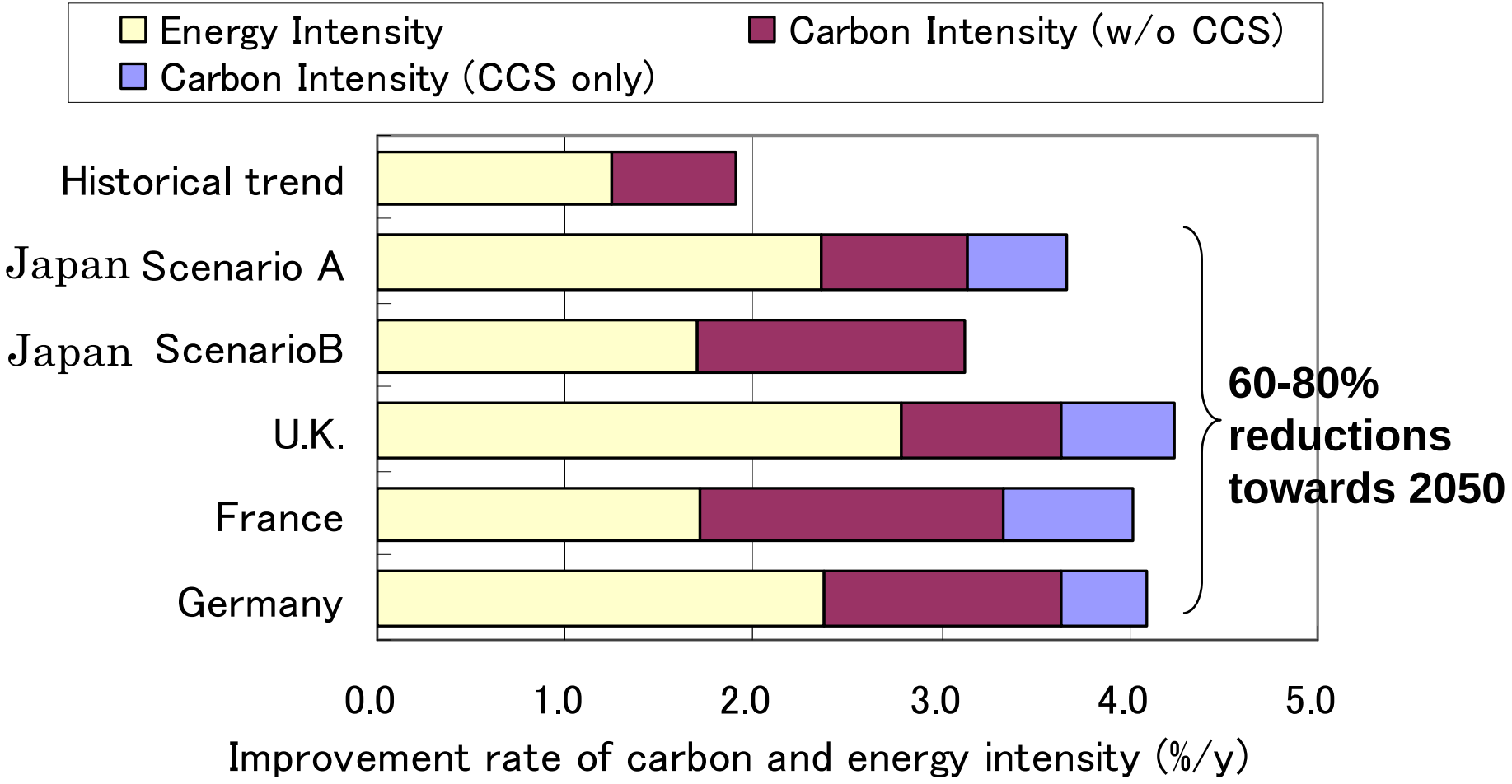
Target for Low Carbon Society

Shuzo Nishioka, Junichi Fujino;
NIES COP11 and COP/MOP1 side event
Global Challenges Toward
Low-Carbon Economy (LCE), Dec.3, 2005

How fast we need to reduce GHG emissions



Required improvement rate of carbon and energy intensity to achieve LCS

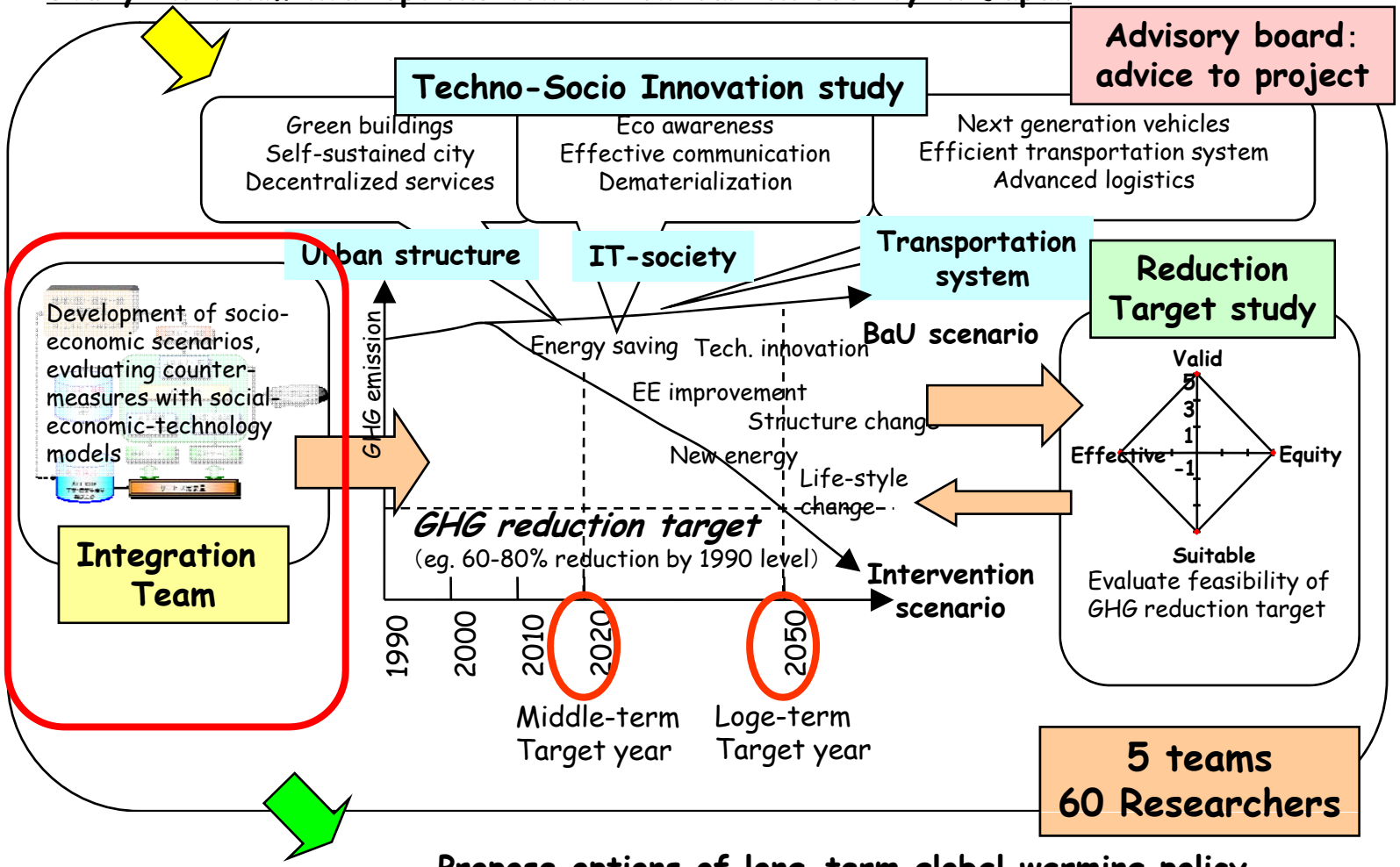


Keep double speed to improve carbon and energy intensity compared as that of the historical record!

Japan Low Carbon Society Scenarios toward 2050

[FY2004-2008, Global Environmental Research Program, MOE]

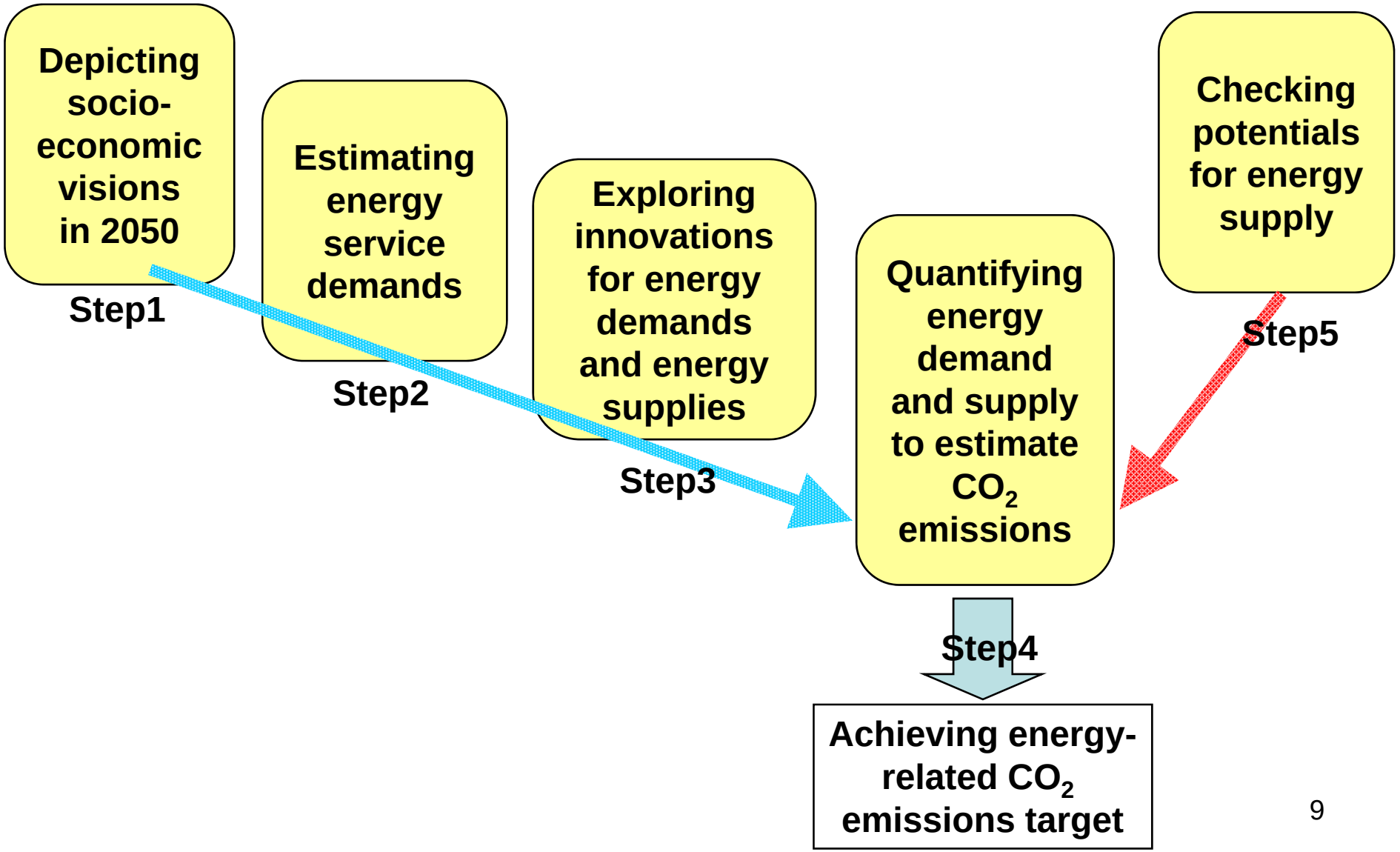
Study environmental options toward low carbon society in Japan



Propose options of long-term global warming policy

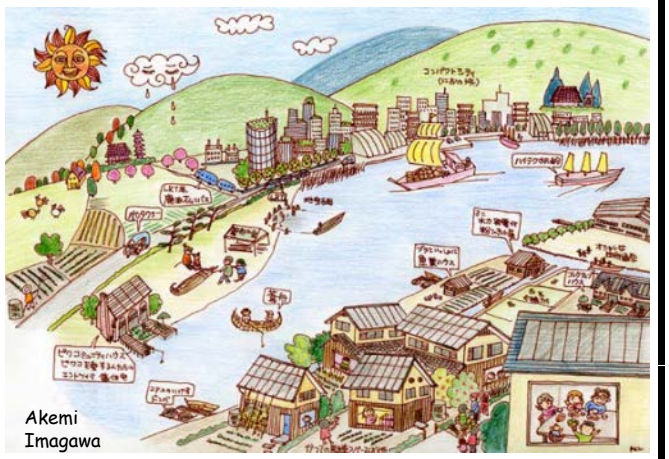
Japan LCS (Low-Carbon Society) (FY2004-2008)
Research Project supported by
Global Environmental Research Fund, MOEJ

Scenario Approach to Develop Japan Low-Carbon Society (LCS)



Visions

we prepared two different but likely future societies for Japan

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
	

We prepared models to quantify the LCSs

Element models;

1) Snapshot models;

Inter-sector and Macro Economic model

Energy technology bottom-up models

Energy supply model

Transportation demand model

2) Transition models;

Population and household model

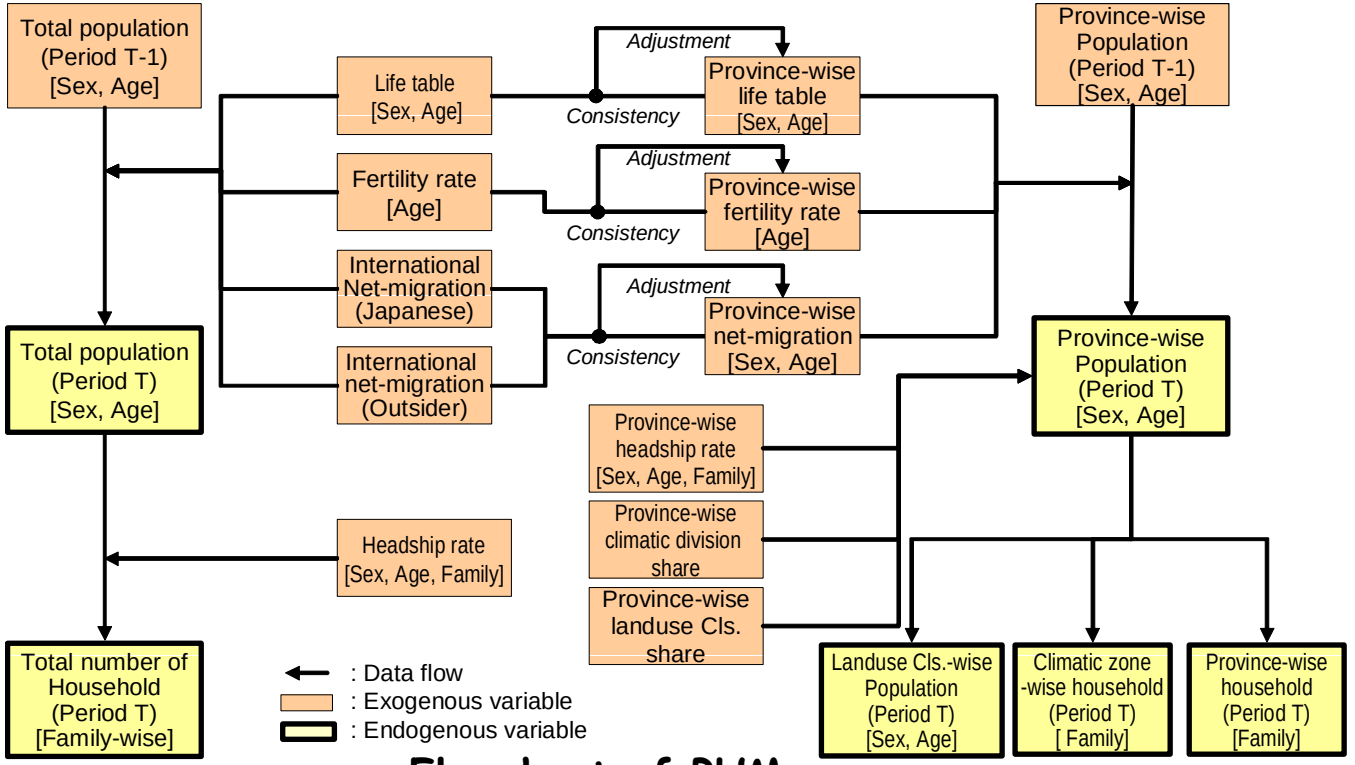
Building dynamics model

Integration tool;

Snapshot Integration Tool (SSI)

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.

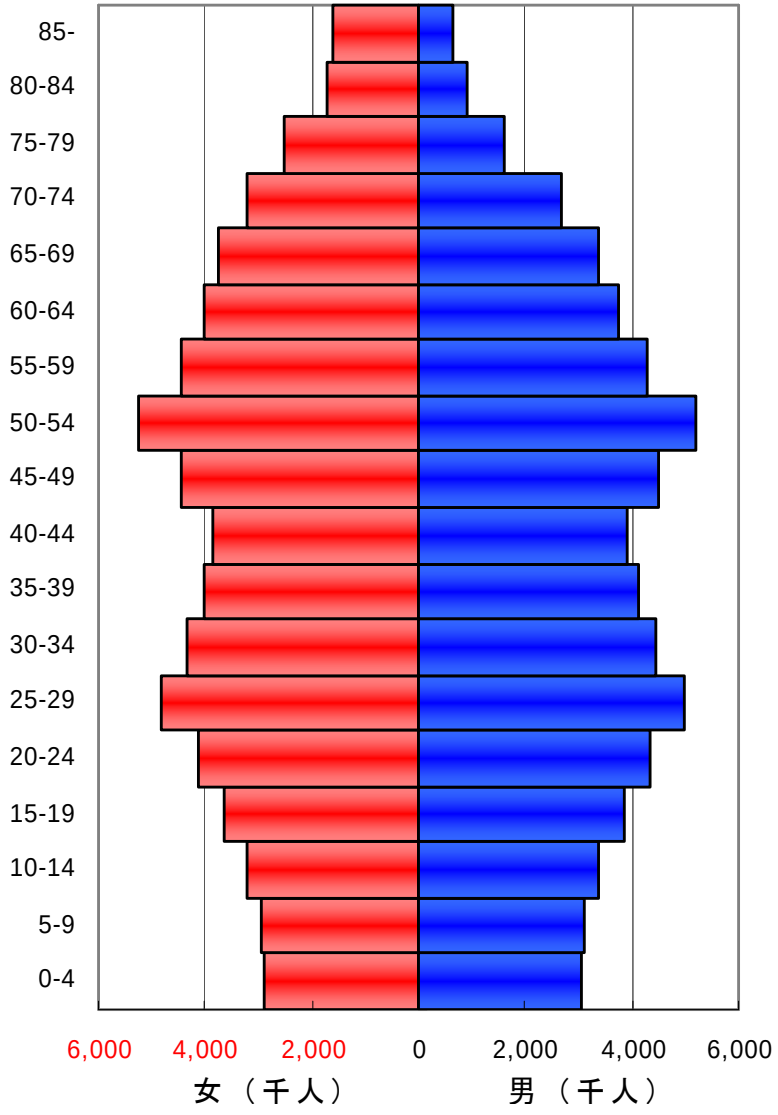


Flowchart of PHM

Population

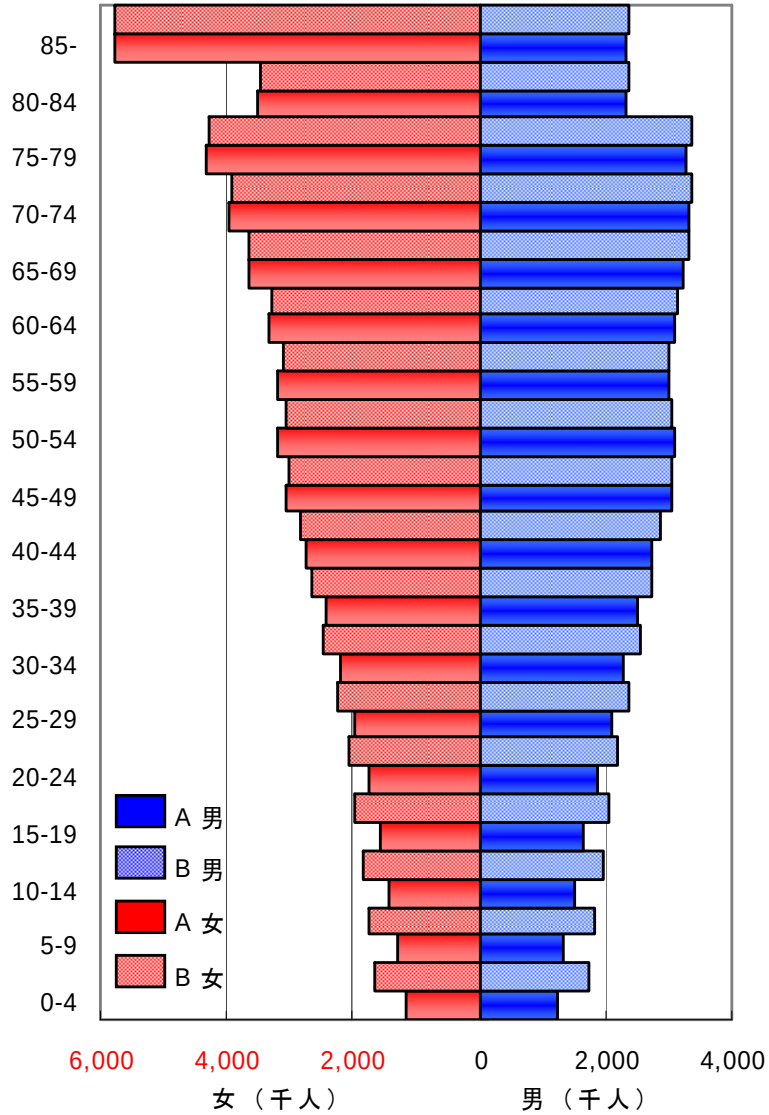
2000年

127billion

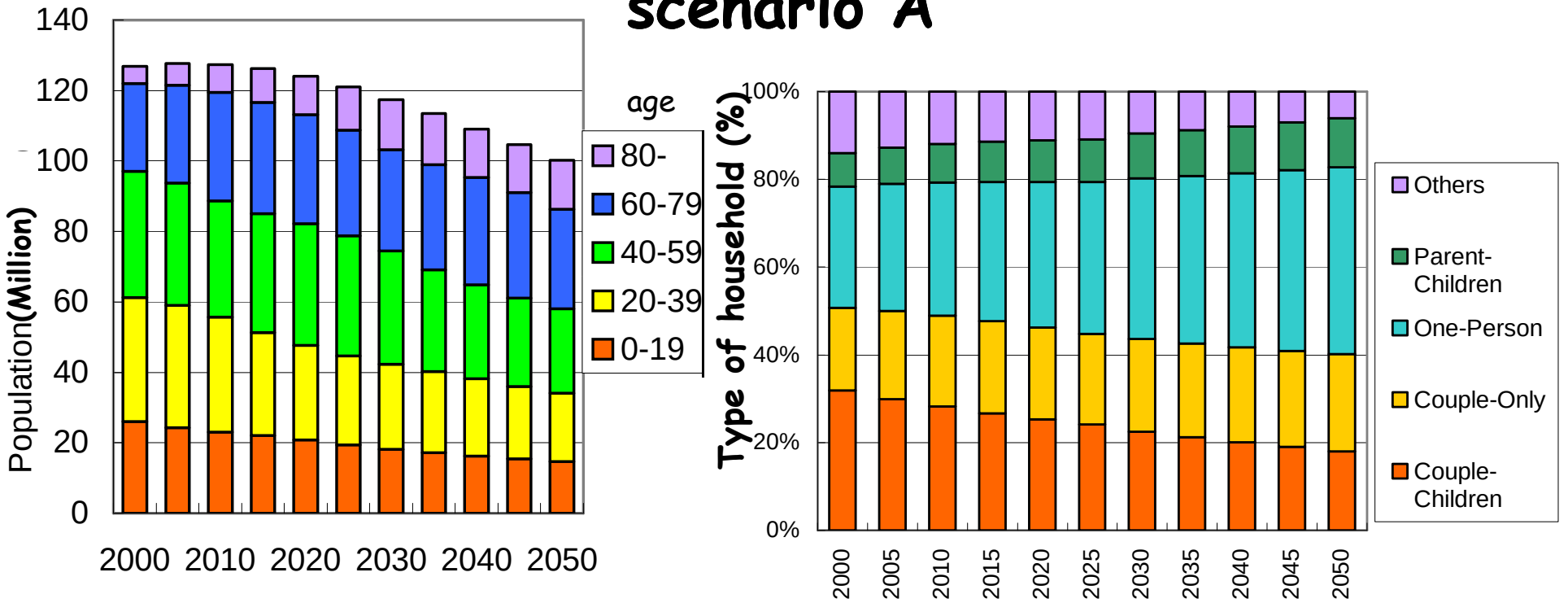


2050年

scenario A: 94bil　scenarioB:100bil



Projection Japan population and households in scenario A



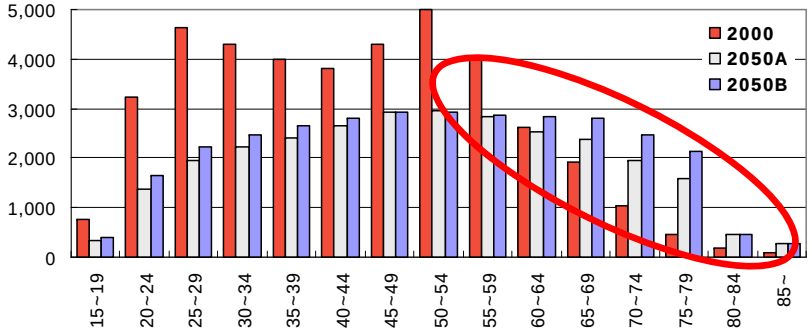
year	2000	2050	
		A	B
Population (million)	126.9	94.5	100.3
Aged population ratio (%)	17.4	53.7	35.8
Average number of household	2.71	2.19	2.38
Single-person households (%)	27.6	42.6	35.1

Labor Force and Working time

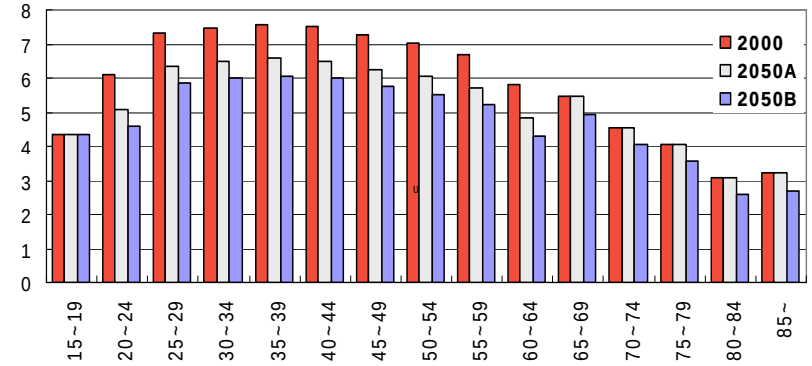
2000年
2050年A
2050年B

M

Employee (1000)



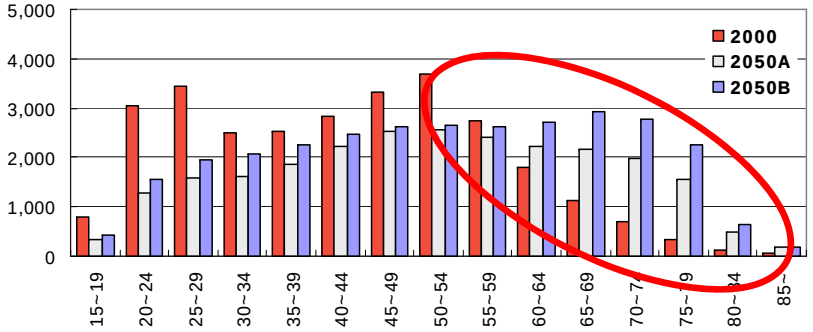
Working time (men, hour/day)



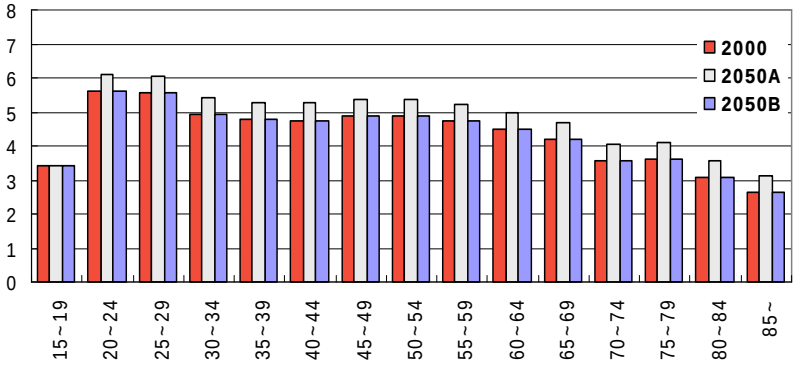
age

F

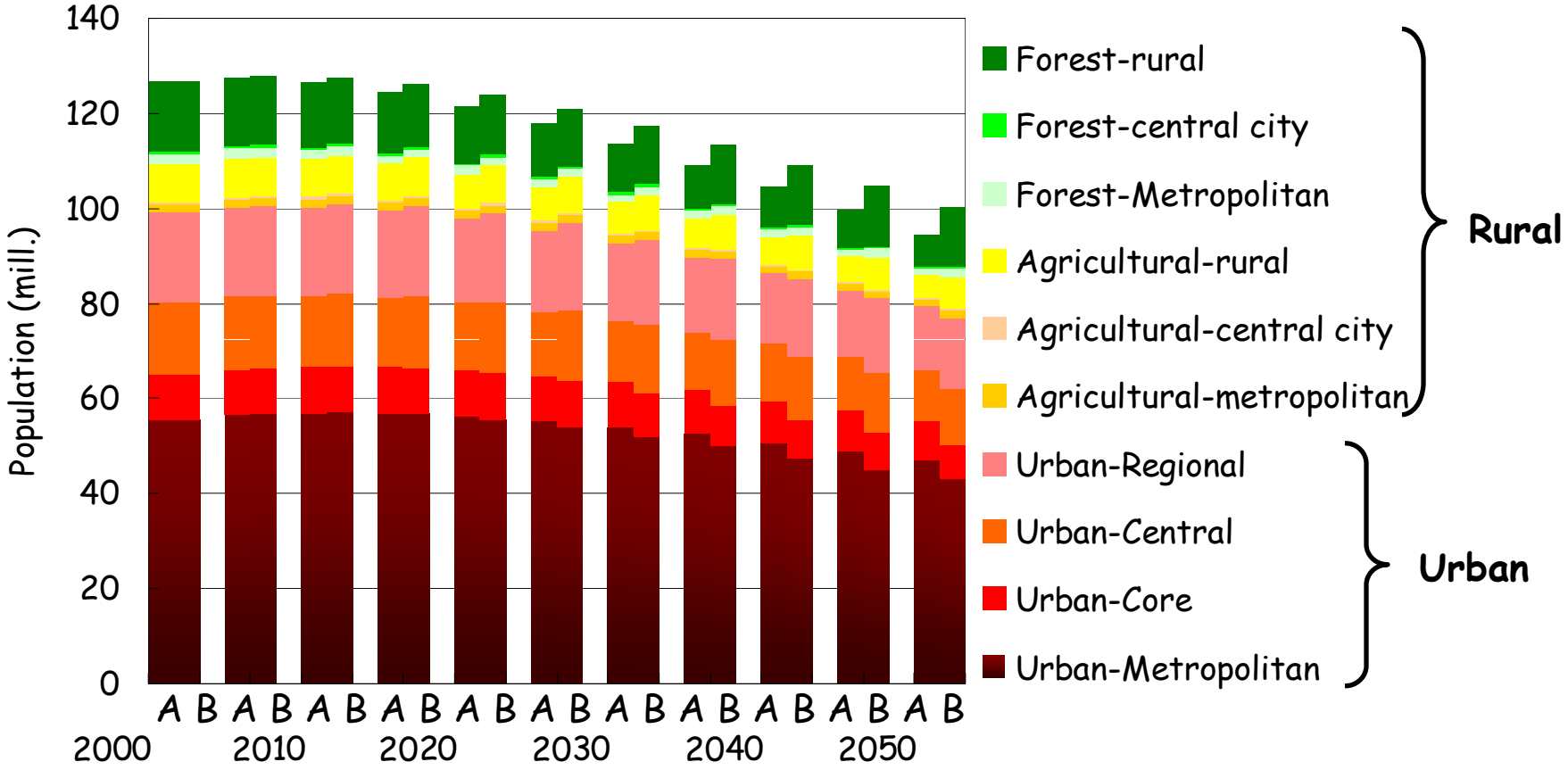
Employee (1000)



Working time (men, hour/day)



Projection of urbanization



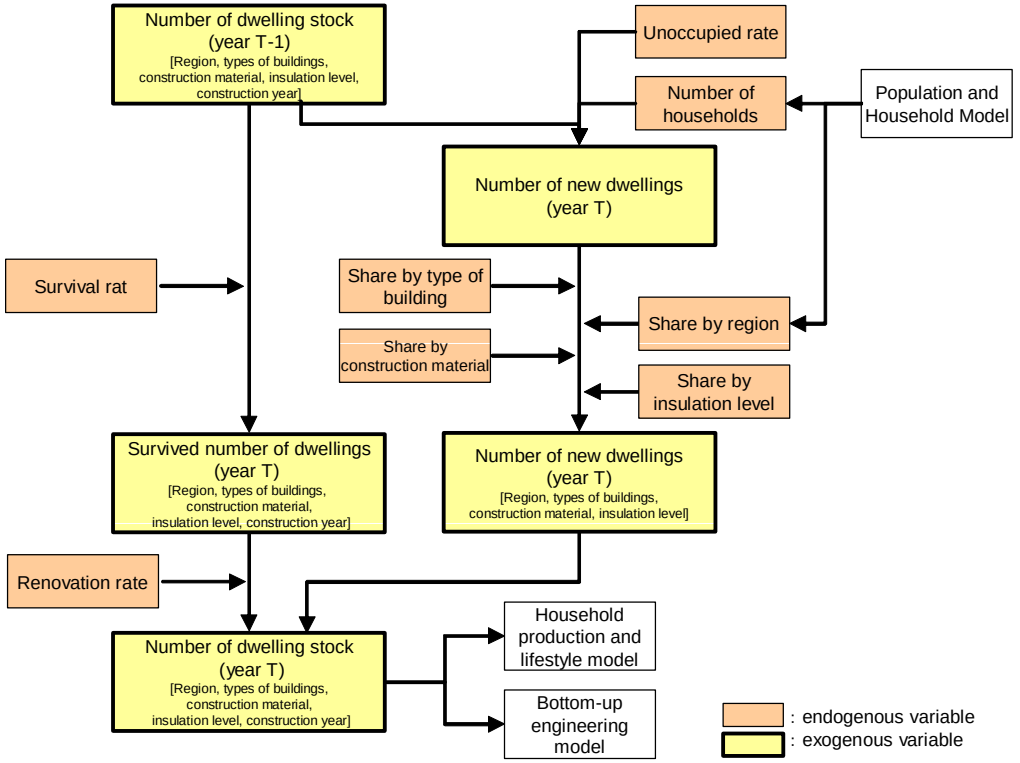
year	2000	2050	
		A	B
Population (million)	126.9	94.5	100.3
Urban population(%)	78.1	84.2	76.7
Agricultural area population(%)	8.2	7.1	8.5
Forest area population(%)	13.7	8.7	14.8

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.

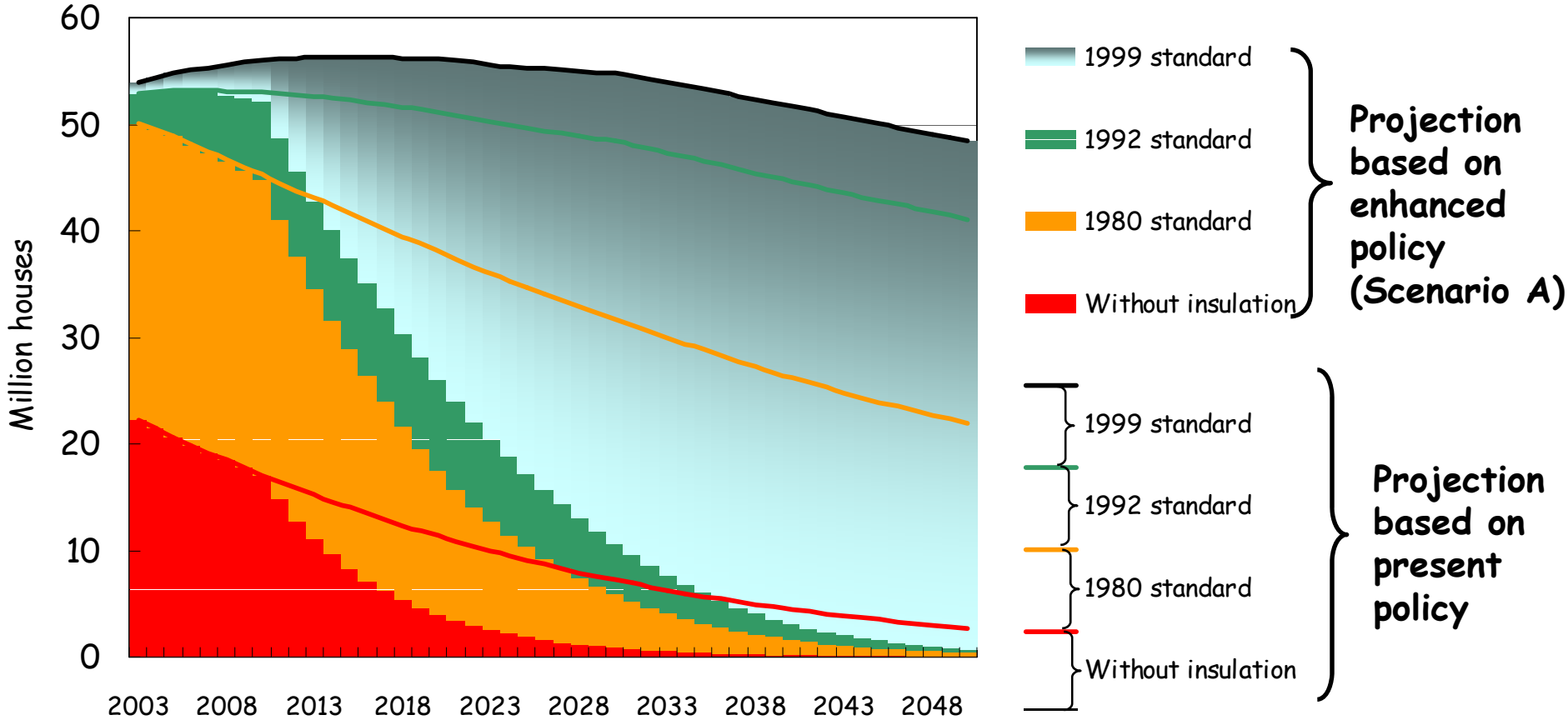
- In order to take account these factors, a model of building dynamics (BDM) was developed.

- 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, Scenario A

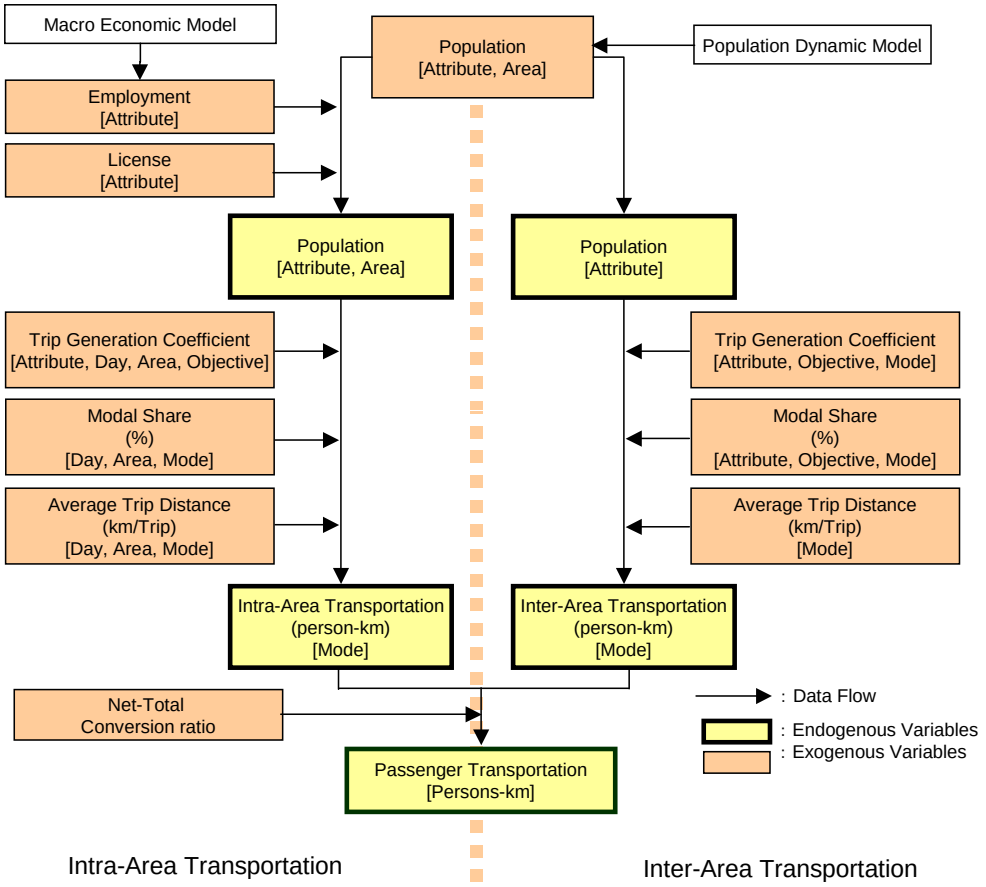


Passenger Transportation Demand Model

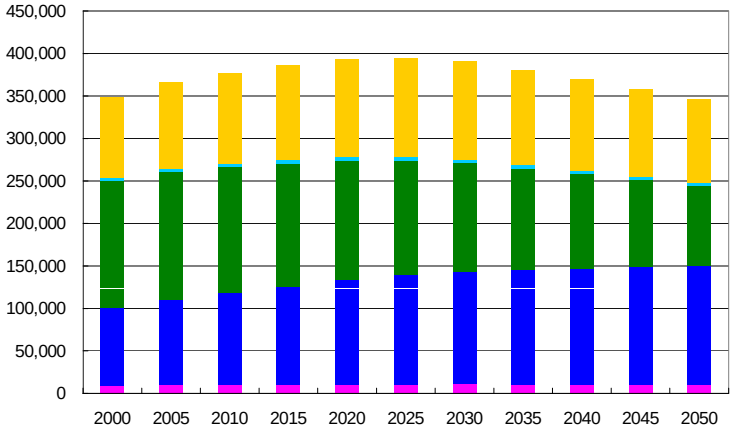
- Many effective countermeasures exist related with transportation. Modal shift from private motor vehicles to mass transit systems, urban planning towards compact cities, transportation substitution with diffusions of teleworking and virtual communication systems and so on.
- Passenger Transportation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

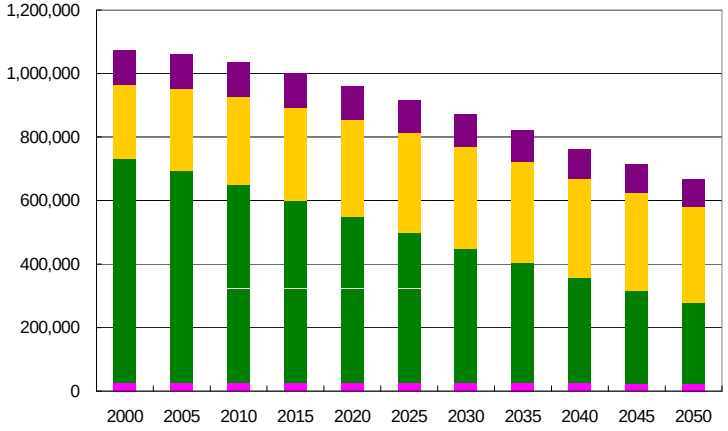
  and they are calculated separately.



Passenger Transportation Demand Model (2)
Scenario A



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



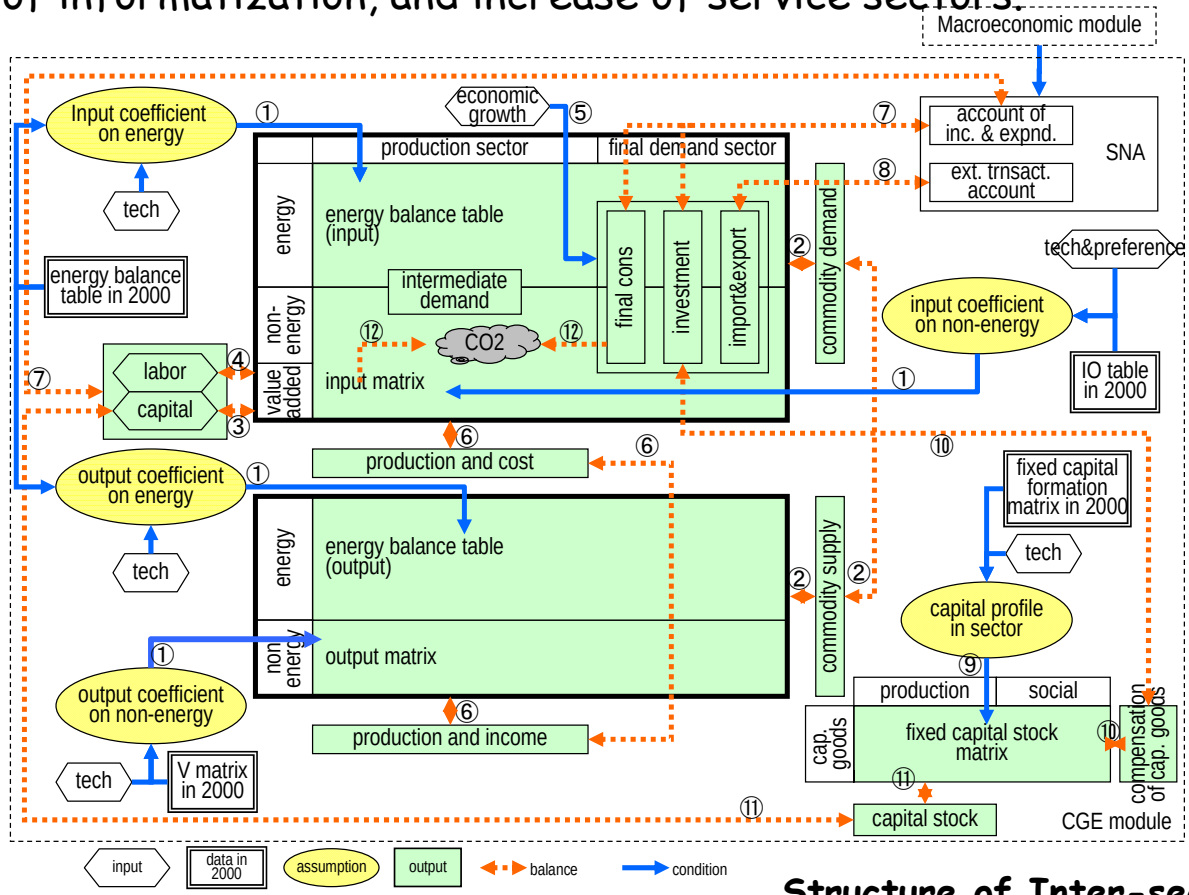
Intra-region transportation demand by mode of transportation (mil. person-km)

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.

Inter-sector and Macro Economic Model

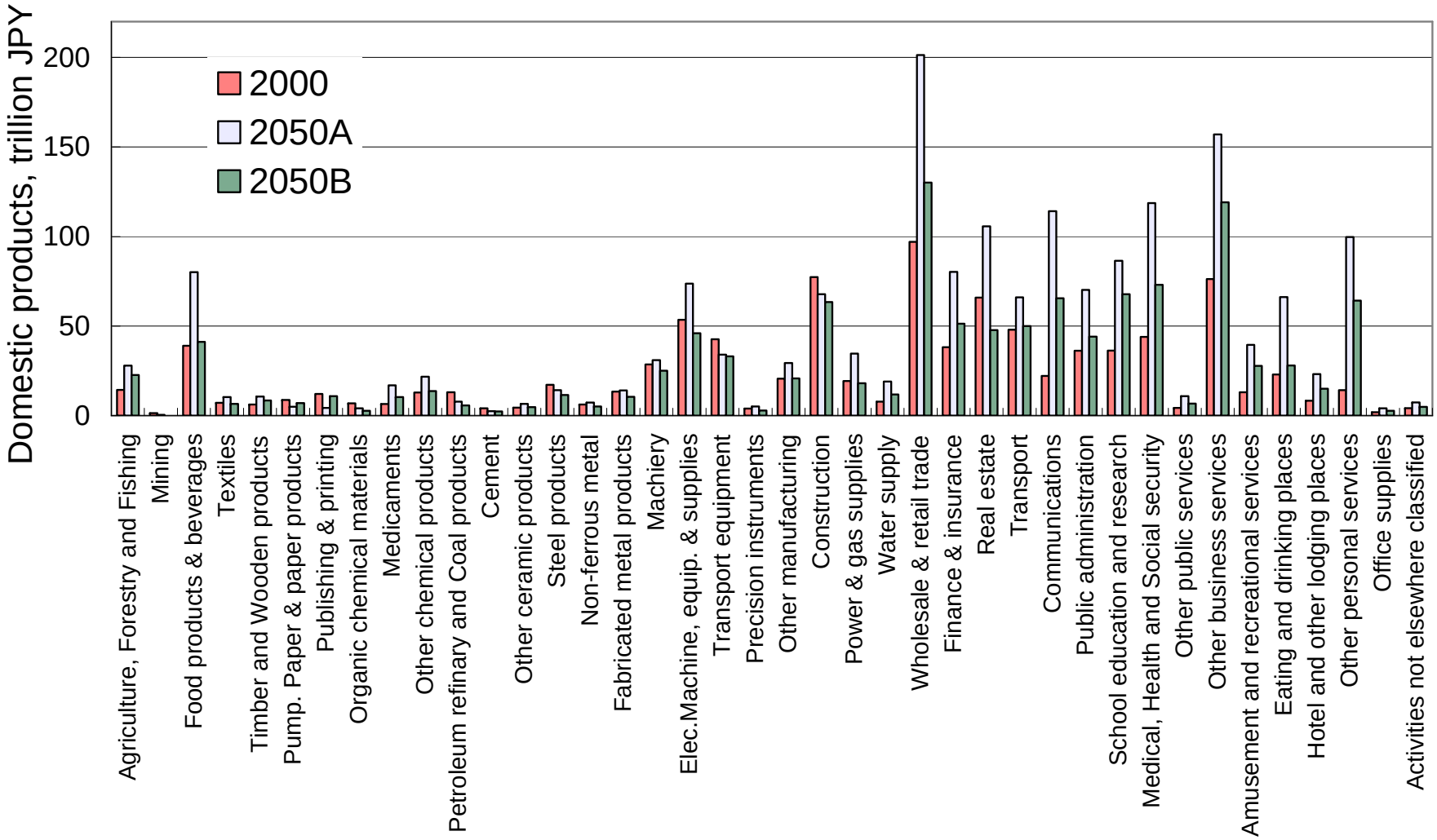
- Projecting macro economic activity, sectoral production, and also taking account the countermeasures proposed in the individual models, we developed "Inter-sector and Macro Economic Model (IMEM)", which consists of a sequential dynamic general equilibrium module and a macroeconomic module.
- The model 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.



Structure of Inter-sector Module

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

Projected sector productions in year 2050



Quantification of Scenario A and B in 2050

year	unit	2000	2050 A	2050 B	model
Population	Mil.	127	94 (74%)	100 (79%)	Population and Household model
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%)	Inter-sector and Macro Economic Model
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 & Inter-sector and Macro Economic Model
Travel Passenger volume	bill. p·km	1,297	1045 (81%)	963 (74%)	Transportation demand model & Inter-sector and Macro Economic Model
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%)	Inter-sector and Macro Economic Model
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

Visions and Innovations

LCS house in 2050
Comfortable and energy-saving house

Utilizing solar power

Photovoltaic

34-69MW
(25-47% house has PV on roof (now 1%))
and develop high efficiency (<30%) PV

Eco-life education

10-20% energy demand reduction

rooftop gardening

High efficiency lighting
【eg LED lighting】

Reduce 1/2 energy demand
Share 100%

Solar heating

Diffusion rate: 20-60%
（currently 8%）

Monitoring system
equipped with appliances

High-insulation

Reduce 60% warming energy demand,
share 100%

Super high efficiency air conditioner

COP (coefficients of performance=8),
share 100%

Fuel cell

share 0-20%

Heat-pump heating

COP＝5
share 30-70%

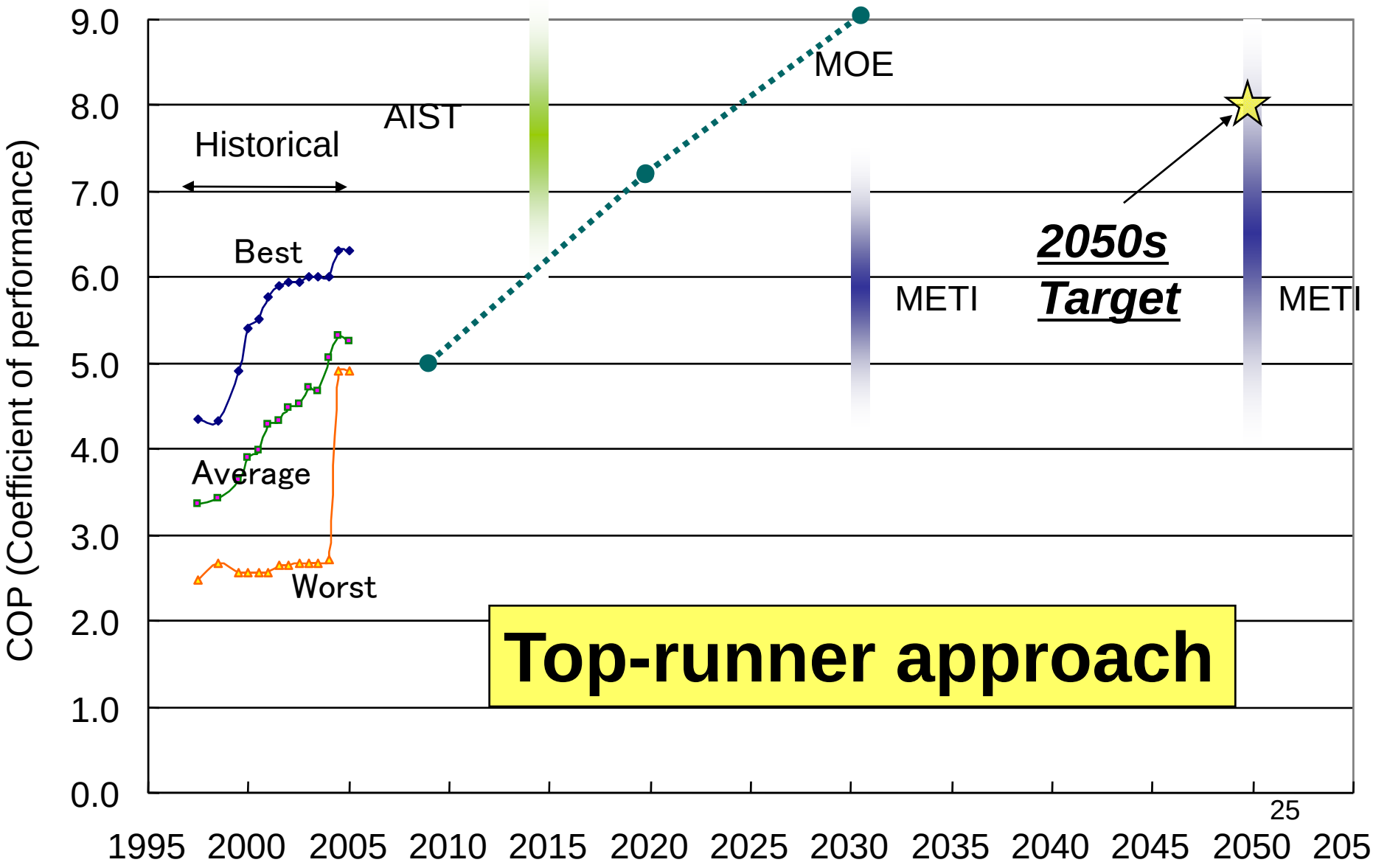
Stand-by energy reduction

Reduce 1/3 energy demand,
share 100%

Good information for economy and environment makes people's behavior low-carbon

High efficiency appliances reduce energy demand and support comfortable and safe lifestyle

Projected energy efficiency improvement: Air-conditioners for cooling and heating



Res/Com		2000	2030	2050	2100
Total energy demand		1 time		1.5 times	2.1 times
Energy supplied from transformation sector*	Residential		45% reduction	60% reduction	80% reduction
	Commercial		35% reduction	55% reduction	80% reduction
CO_2 intensity	Residential	3.5 t-CO_2/household (1 time)	1.9 t-CO_2/household (1/2 times)	1.1 t-CO_2/household (1/3 times)	0 t-CO_2/household
	Commercial	118 kg-CO_2/m^2 (1 time)	77 kg-CO_2/m^2 (2/3 times)	40 kg-CO_2/m^2 (1/3 times)	0 kg-CO_2/m^2

*The percentage of reduction of energy per unit should be supplied from the transformation sector, compared with total energy demand increases in proportion to GDP.

Energy saving

Efficiency improvement of equipment

- *Lighting with less heat loss* → *Equipment with less heat loss*
- *Improving thermal performance of housing and building* → *Active control of sun shading and thermal insulation*
- *Efficient heating* → *Efficient heat transfer, preheating by unused energy*
- *Improving electric power conversion efficiency* → *Electric power conversion with least loss*
- *Food storage at room temperature*

Utilization of ubiquitous energy
(minute pressure, temperature difference, vibration, radiowaves, etc.)

- *Energy saving enables equipment using little energy*
- *Energy creation from ubiquitous energy*

Photovoltaic generation

- *Installation in all places such as PV paint*
- *Installation in windows*
- *Installation in curved surfaces*
- *Installation facilitation*

Energy creation

- *Efficiency improvement and increase of durability*

Energy management

BEMS•HEMS

Self-sustainable housing and building

- *Demand management* → *Management of demand and energy creation* → *Energy accommodation in community*
- *(Energy supply in community)* → *Supply and storage management in community* → *Supply and demand management in community*

TEMS

Self-sustainable community

Self-sustaining

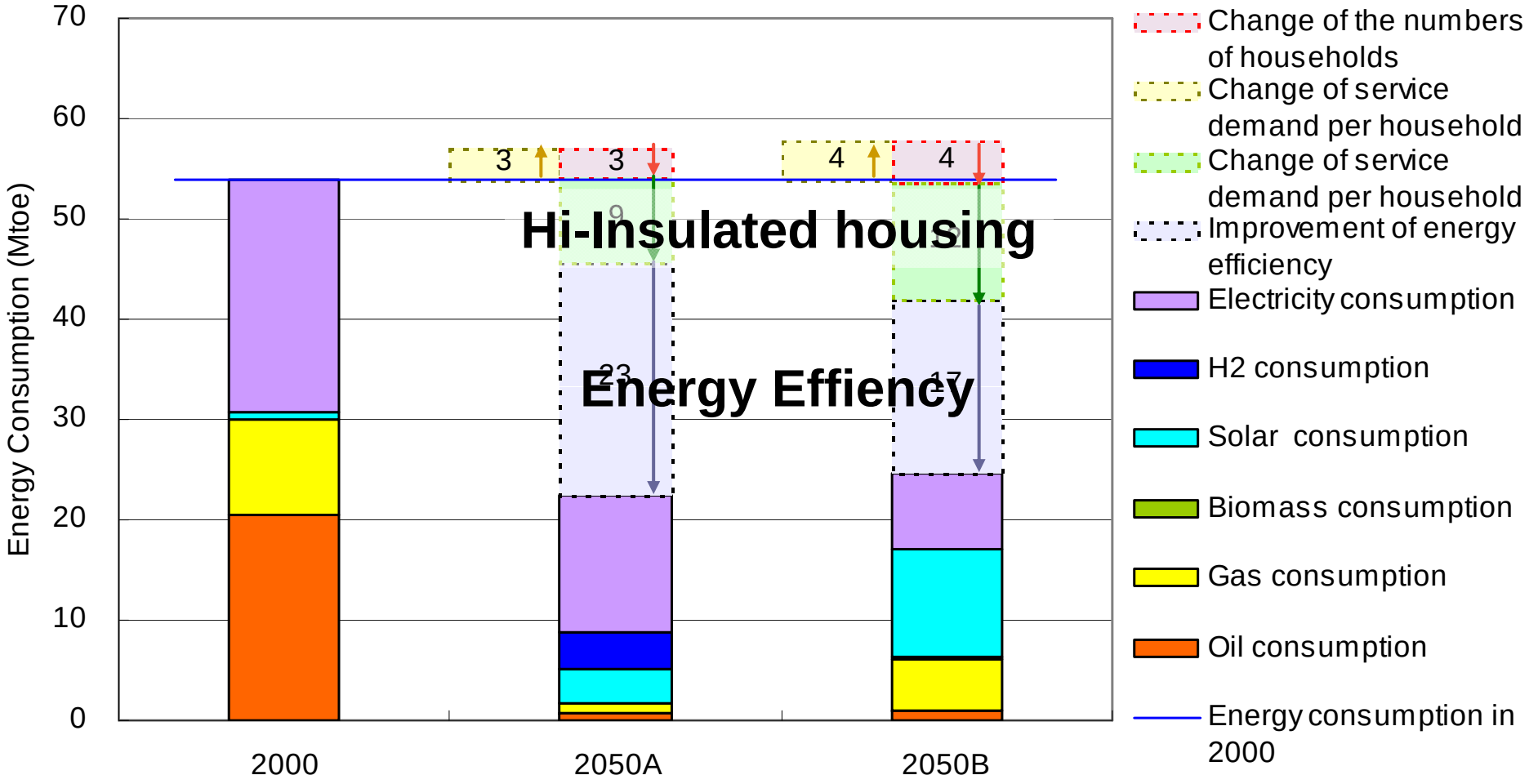
0 t-CO_2/household

0 kg-CO_2/m^2

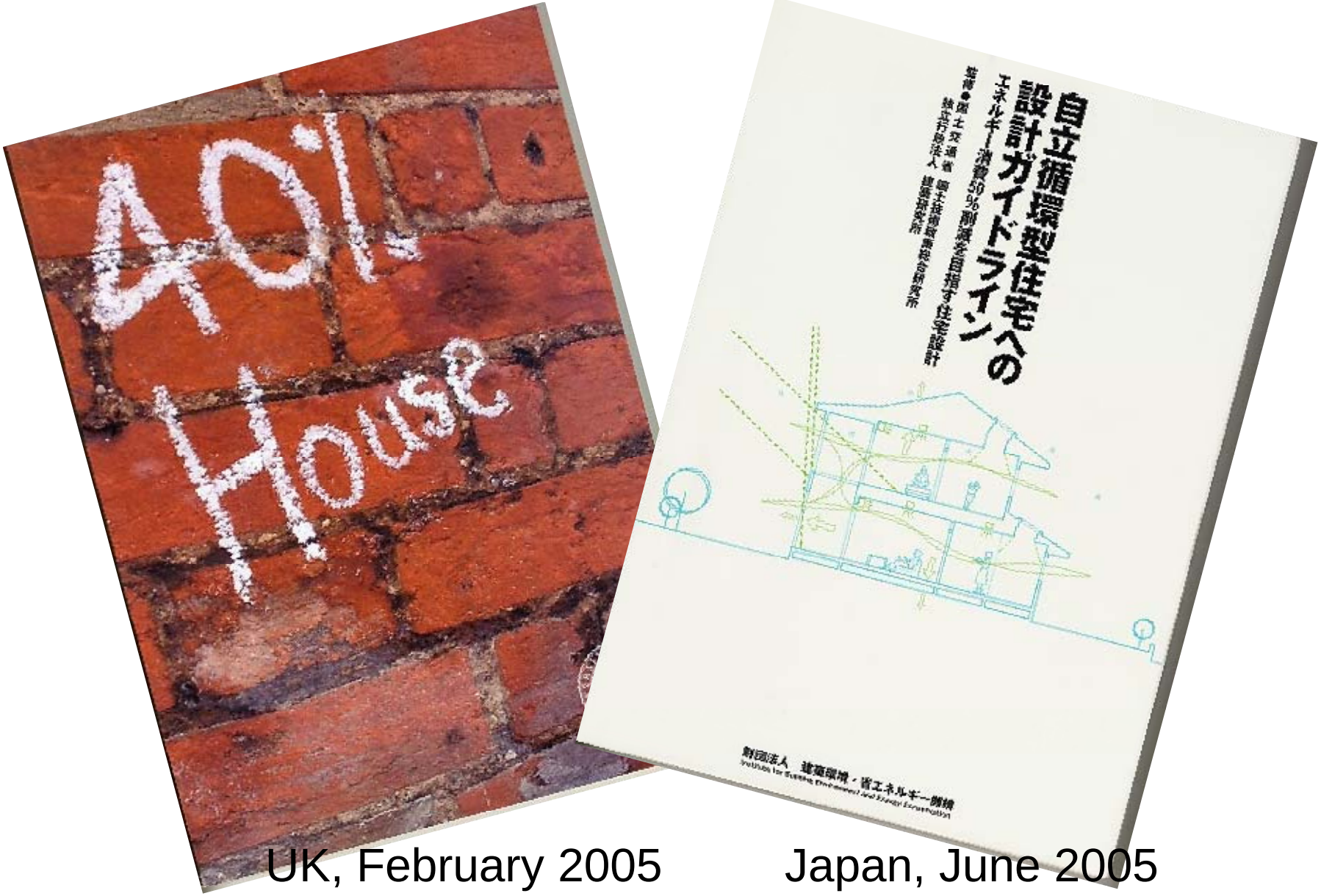
Energy Technology Roadmap 2100 (METI, Japan)
http://www.iae.or.jp/2100.html

Residential sector
Energy reduction potential: 40-50%

Innovations



Change of the number of households: the number of households decrease both in scenario A and B
Change of service demand per household: convenient lifestyle increases service demand per household
Change of energy demand per household: high insulated dwellings, Home Energy Management System (HEMS)
Improvement of energy efficiency: air conditioner, water heater, cooking stove, lighting and standby power



UK, February 2005
"40% House"
60% reductions

Japan, June 2005
Guidance for Self-sustained
Residential, 50% reductions

http://www.ukerc.ac.uk/TheMeetingPlace/Activities/Activities2007/0706AchievingSustainableLCS.aspx

How to reduce CO2 emissions from passenger transportation sector

Demand management
e.g. by information-communication technology
[transport-service per capita]

(1-0.2)x(1-0.2)x(1-0.2)x(1-0.2)x(1-0.2)x(1-0.2)=0.26

Modal shift to reduce CO_2 EF per passenger-km or ton-km

Improve fuel economy
[Fuel consumption per vehicle-km]

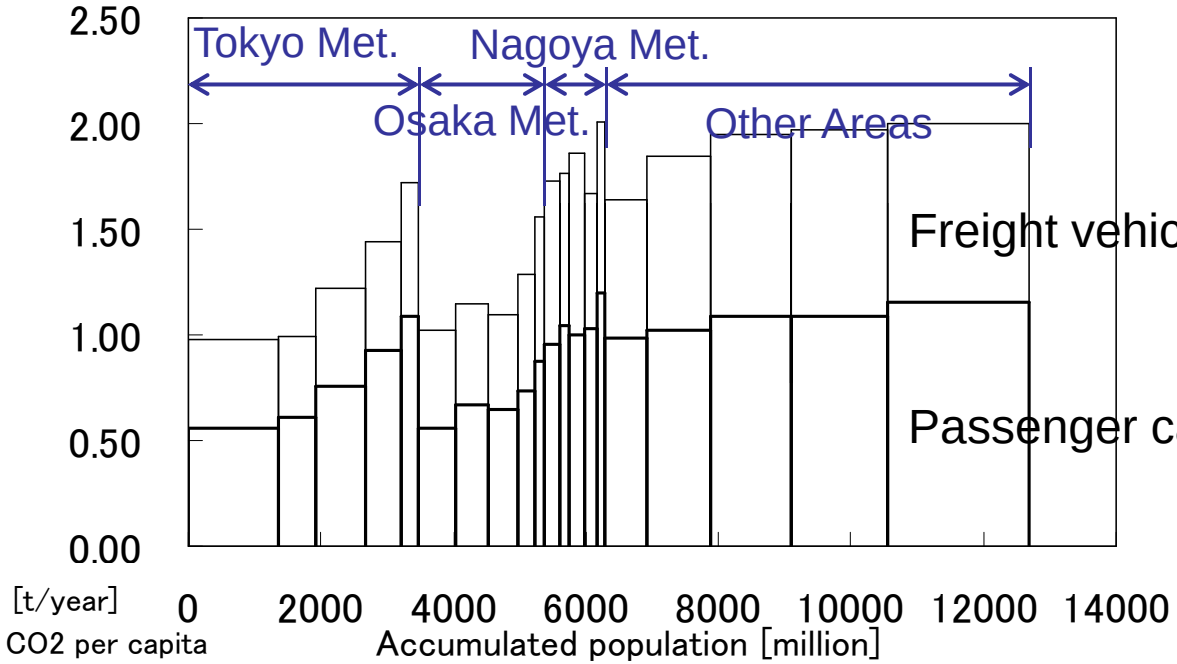
$$\frac{CO_2}{capita} = \frac{TransServ}{capita} \times \frac{Pkm(Tkm)}{TransServ} \times \sum_{Mode} \left(\frac{Vkm}{Pkm(Tkm)} \times \frac{Fuel}{Vkm} \times \frac{CO_2 EF}{Fuel} \right)$$

Improve load factor
[vehicle-km per Pkm(Tkm)]

Improve accessibility
[passenger-km or ton-km per transport-service]

Introduce low carbon energy
[CO_2 emission factor per fuel consumption]

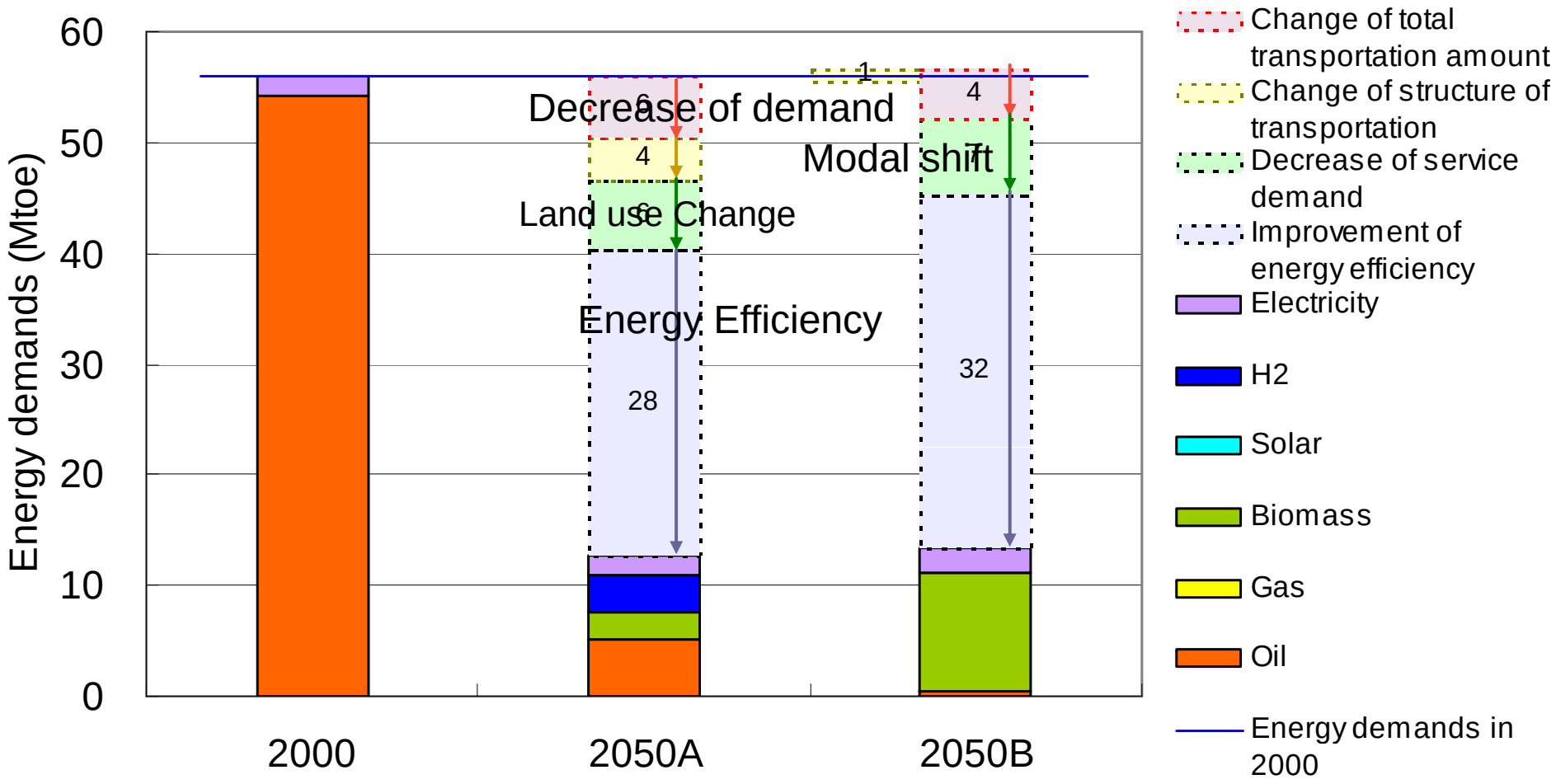
Estimated regional automotive CO_2 emissions



Each Area is categorized in
1. Major cities
2. Cities with a pop of 0.5 million and above
3. Cities with a pop of 0.3 and above
4. Cities with a pop of 0.1 and above
5. Cities with a pop less than 0.1 million
6. Counties

Yuichi Moriguchi, 2nd Japan-UK joint research project workshop (2007.6)

Passenger transportation
Energy demand reduction potential: 80%



New concepts for personal mobility

the Segway Human Transporter

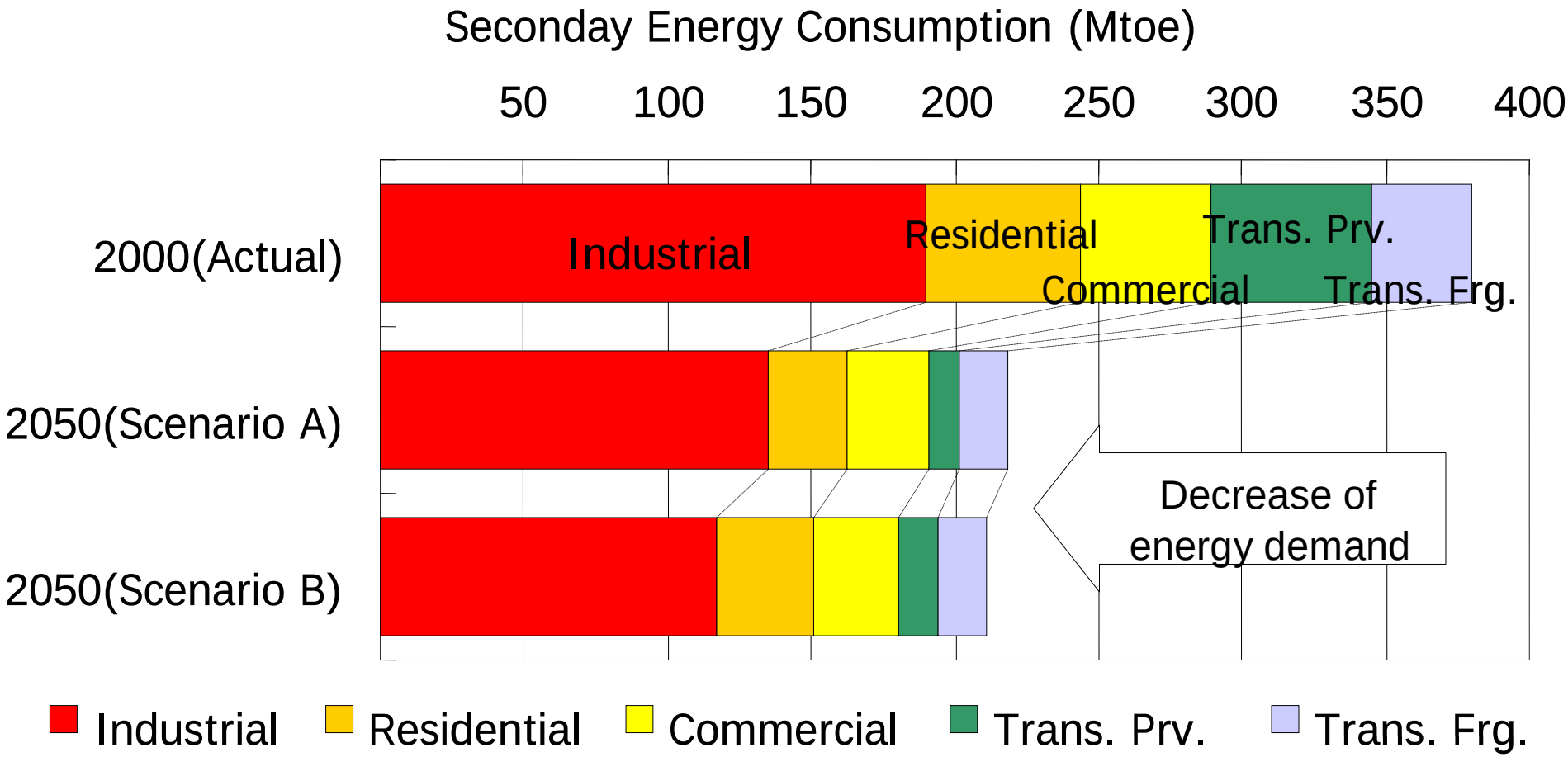
Yamaha EC-02

$$\frac{Vkm}{Pkm(Tkm)} \quad \frac{Fuel}{Vkm} \quad \frac{CO_2EF}{Fuel}$$

Kawamura cycle KE

Toyota i-Swing

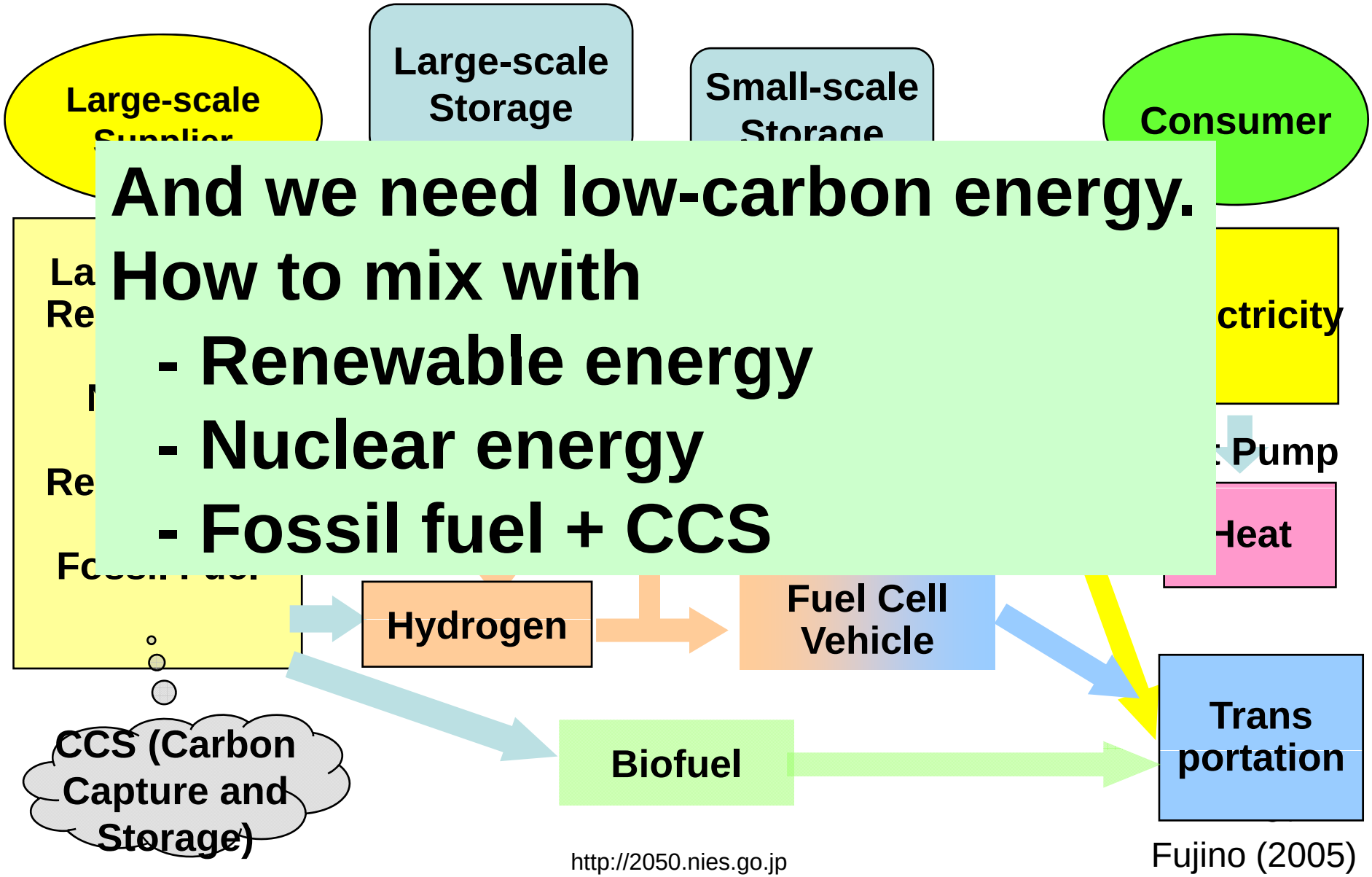
(catalog information)



Trans. Prv.: Transportation (Private), Trans. Frg.: Transportation (Freight)

Possible energy demands reductions for each sector:
Industry：structural change and introduction of saving energy tech. 30～40%
Passenger Transport :land use, saving energy, carbon-intensity change 80%
Freight Transport :efficient transportation system, energy efficient 50%
Residential: high-insulated and energy-saving houses 40-50%
Commercial: high-insulated building and energy saving devices 40%

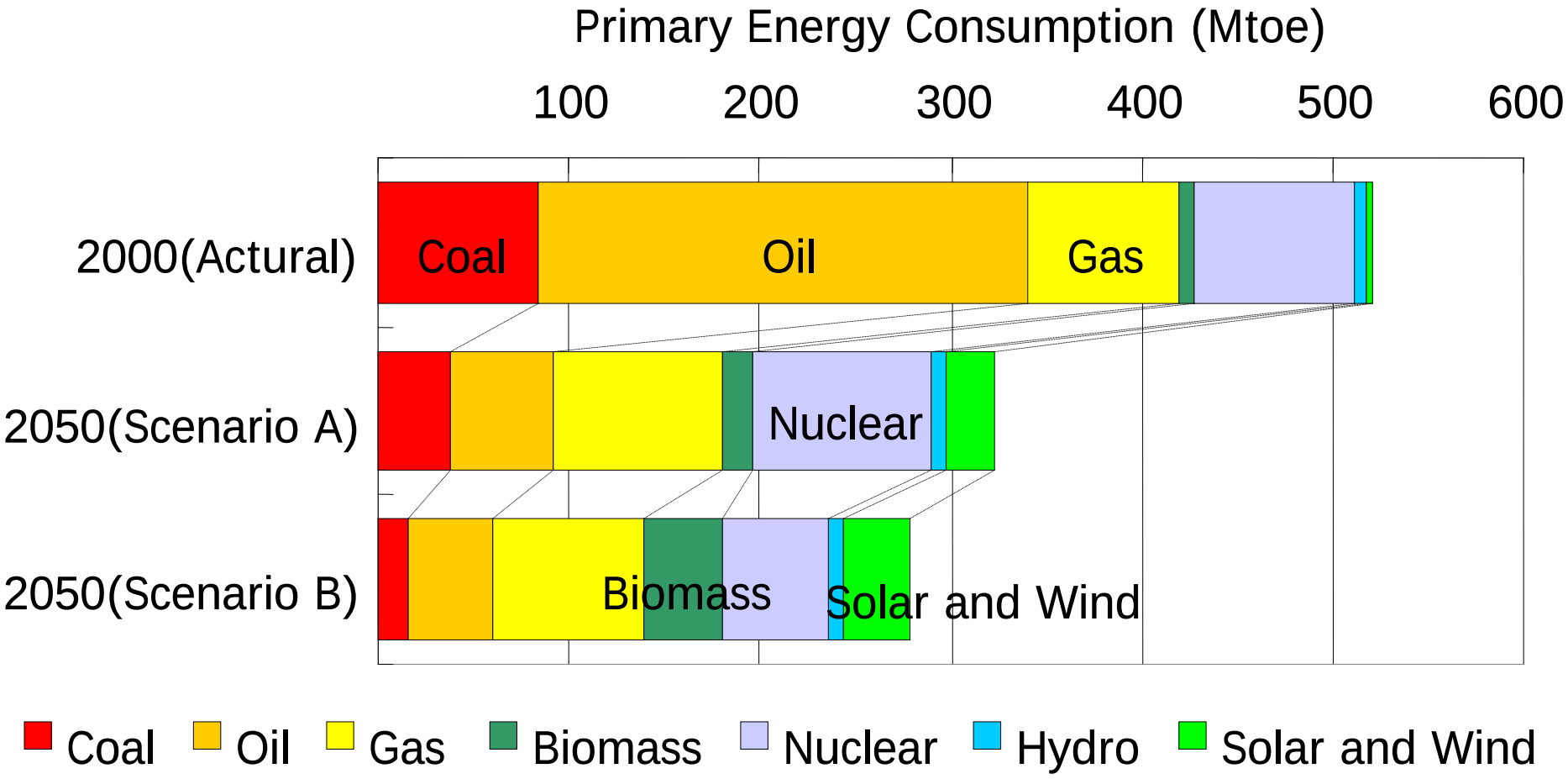
What is Low Carbon Energy Supply System?



http://2050.nies.go.jp

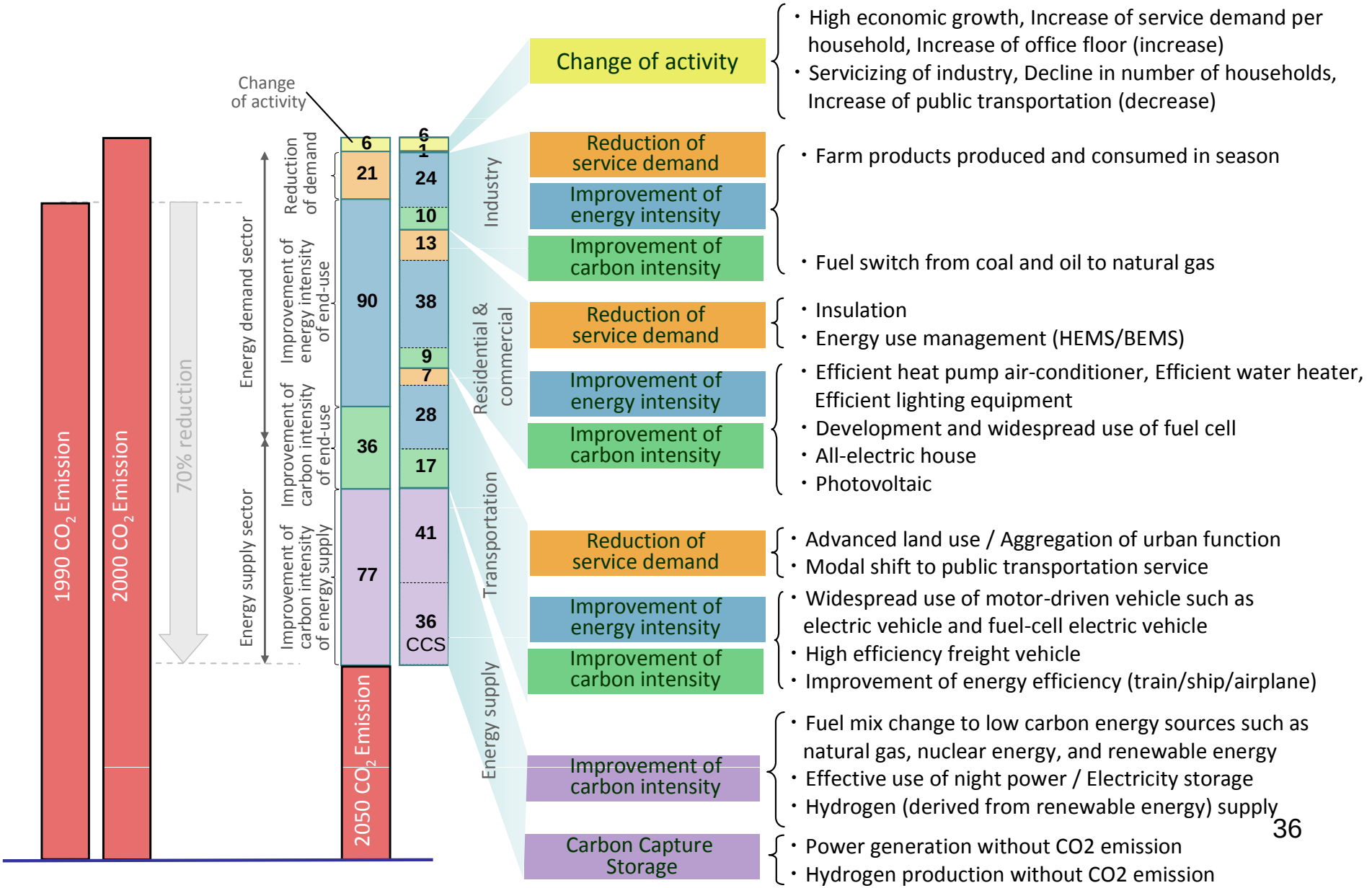
Fujino (2005)

Energy supply for achieving 70% reduction of CO_2 emissions



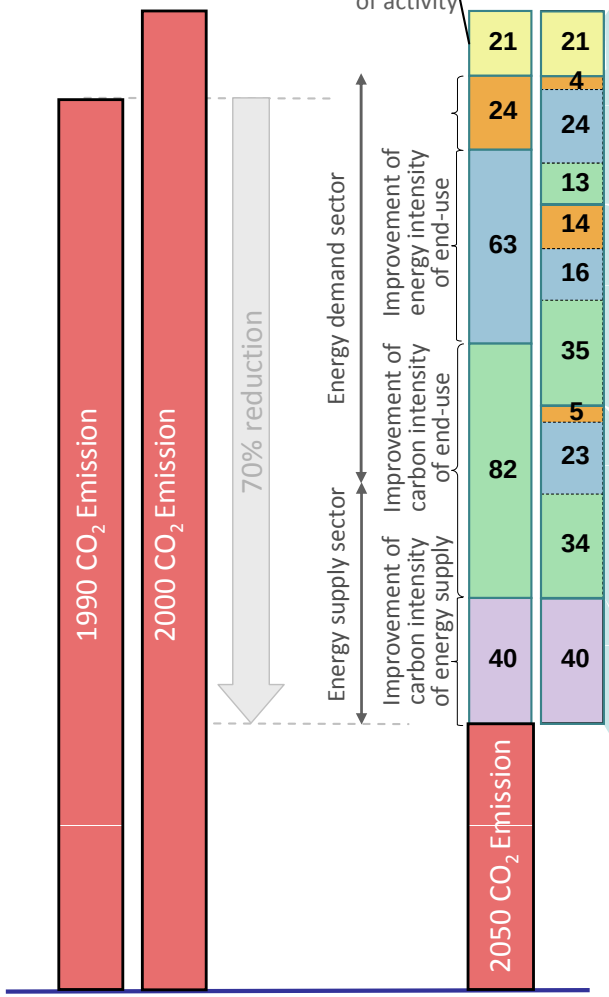
GHG 70% reduction in 2050 Scenario A: Vivid Techno-driven Society

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



GHG 70% reduction in 2050 Scenario B: Slow Nature-oriented Society

Demand side energy -40% ＋ Low carbonization of primary energy＋Renewables with moderate cost of technological options as 0.3% of GDP in the year of 2050



Change of activity

- High economic growth, Increase of service demand per household, Increase of office floor (increase)
- Slowing of final demand by breaking away from physical affluence mind-set, Reduction of war material production, Servicizing of industry, Decline in number of households, Increase of public transportation (decrease)

Industry

Reduction of service demand
- Promoting seasonal local food

Improvement of energy intensity
- Significant improvement in energy efficiency of production equipment

Improvement of carbon intensity
- Fuel switch from coal and oil to natural gas

Residential & commercial

Reduction of service demand
- Insulation
- Energy use management (HEMS/BEMS)

Improvement of energy intensity
- Efficient heat pump air-conditioner, Efficient water heater, Efficient lighting equipment
- Expanding biomass energy use in home

Improvement of carbon intensity
- Diffusion of solar water heating and photovoltaic on the roof

Transportation

Reduction of service demand
- Shortening trip distances for commuting through intensive land use
- Infrastructure for pedestrians and bicycle riders (sidewalk, bikeway, cycle parking)

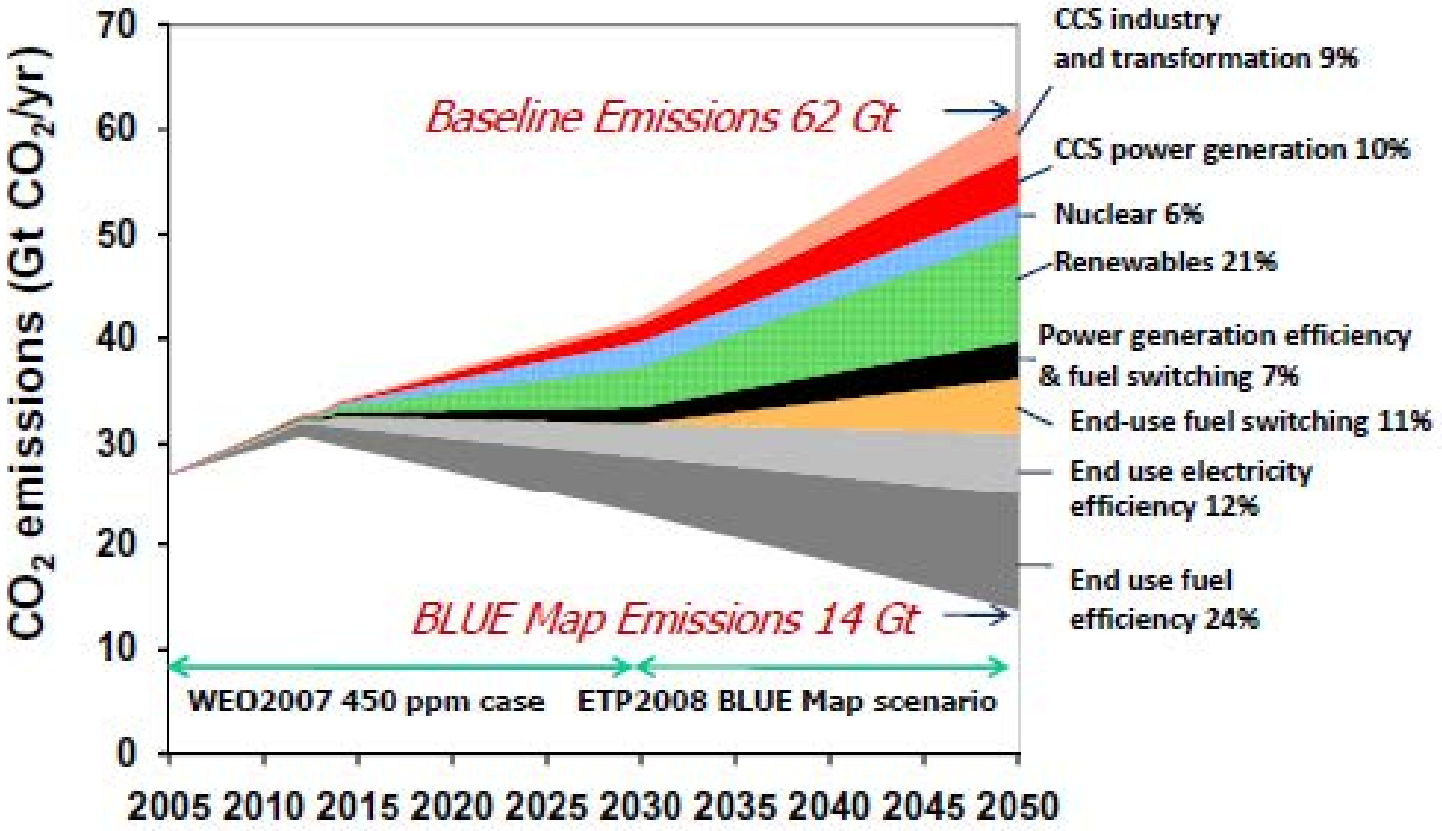
Improvement of energy intensity
- Widespread use of hybrid vehicle
- Expanding biofuels

Improvement of carbon intensity
- Improvement of energy efficiency (train/ship/airplane)

Energy supply

Improvement of carbon intensity
- Expanding share of both advanced gas combined cycle and biomass generation
- Decrease of electricity demand

A New Energy Revolution: Cutting Energy Related CO_2 Emissions



ENERGY TECHNOLOGY PERSPECTIVES 2008

Scenarios & Strategies to 2050

INTERNATIONAL ENERGY AGENCY

A Dozen of Actions towards Low-Carbon Societies

Press release on May 22, 2008

Residential/commercial sector actions

1. Comfortable and Green Built Environment
Efficiently use of sunlight and energy efficient built environment design. Intelligent buildings.

2. Anytime, Anywhere Appropriate Appliances
Use of Top-runner and Appropriate appliances. Initial cost reduction by rent and release system resulting in improved availability.

Industrial sector actions

3. Promoting Seasonal Local Food
Supply of seasonal and safe low-carbon local foods for local cuisine

4. Sustainable Building Materials Using local and renewable buildings materials and products.

5. Environmentally Enlightened Business and Industry Businesses aiming at creating and operating in low carbon market. Supplying low carbon and high value-added goods and services through energy efficient production systems.

Transportation sector actions

6. Swift and Smooth Logistics
Networking seamless logistics systems with supply chain management, using both transportation and ICT infrastructure

7. Pedestrian Friendly City Design
City design requiring short trips and pedestrian (and bicycle) friendly transport, augmented by efficient public transport

Energy supply sector actions

8. Low-Carbon Electricity Supplying low carbon electricity by large-scale renewables, nuclear power and CCS-equipped fossil (and biomass) fired plants

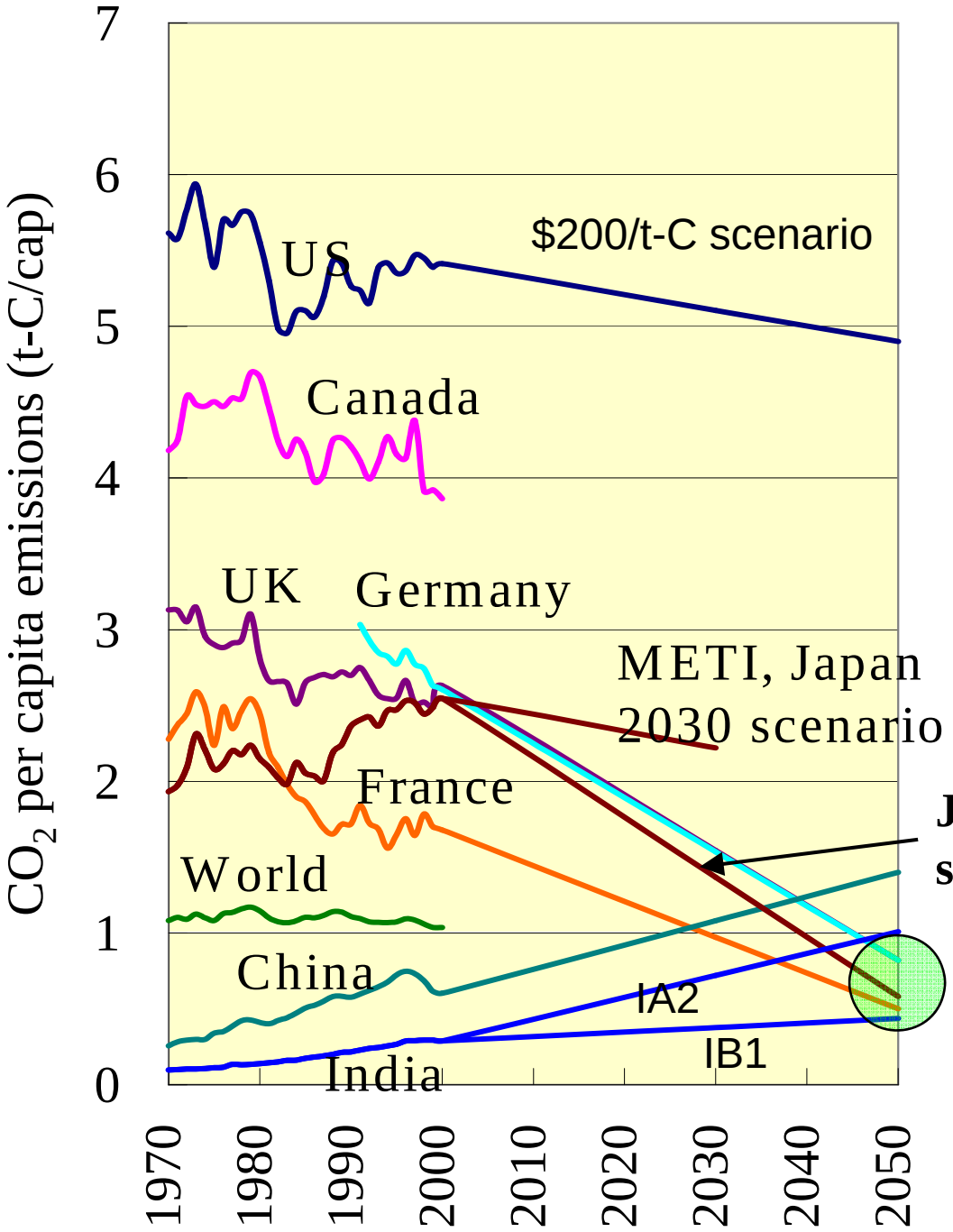
9. Local Renewable Resources for Local Demand
Enhancing local renewables use, such as solar, wind, biomass and others.

10. Next Generation Fuels Development of carbon free hydrogen- and/or biomass-based energy supply system with required infrastructure

Cross-sector actions

11. Labeling to Encourage Smart and Rational Choices
Visualizing of energy use and CO2 costs information for smart choices of low carbon goods and service by consumers, and public acknowledgement of such consumers

12. Low-Carbon Society Leadership Human resource development for building "Low-Carbon Society" and recognizing extraordinary contributions.



Current per capita CO_2 emissions and Target

US: delay for tech development, global warming business

EU: Initiatives toward LCS
Japan: Need long-term vision

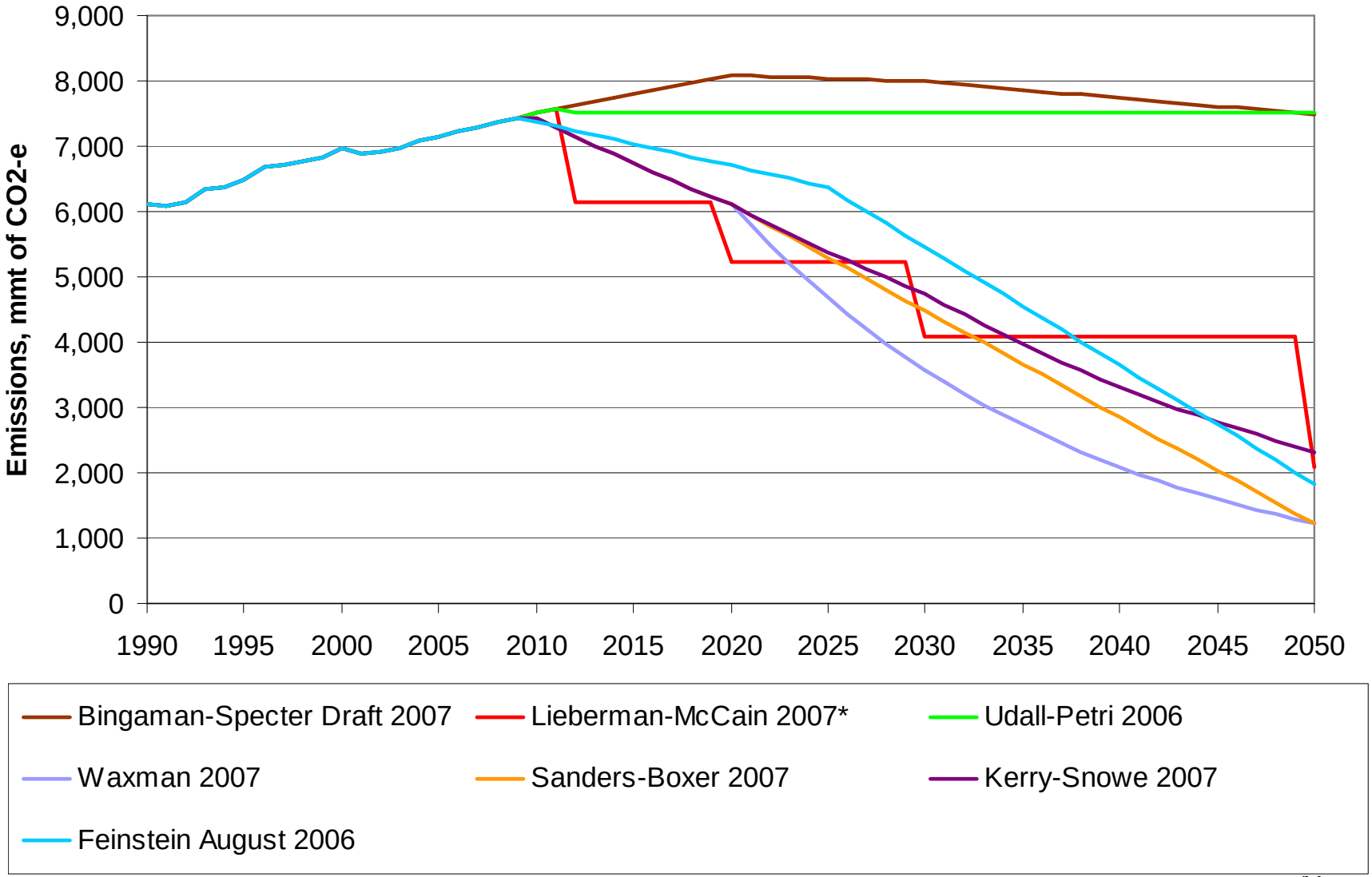
Developing countries: earlier guidance toward LCS is key

Japan 2050 scenario

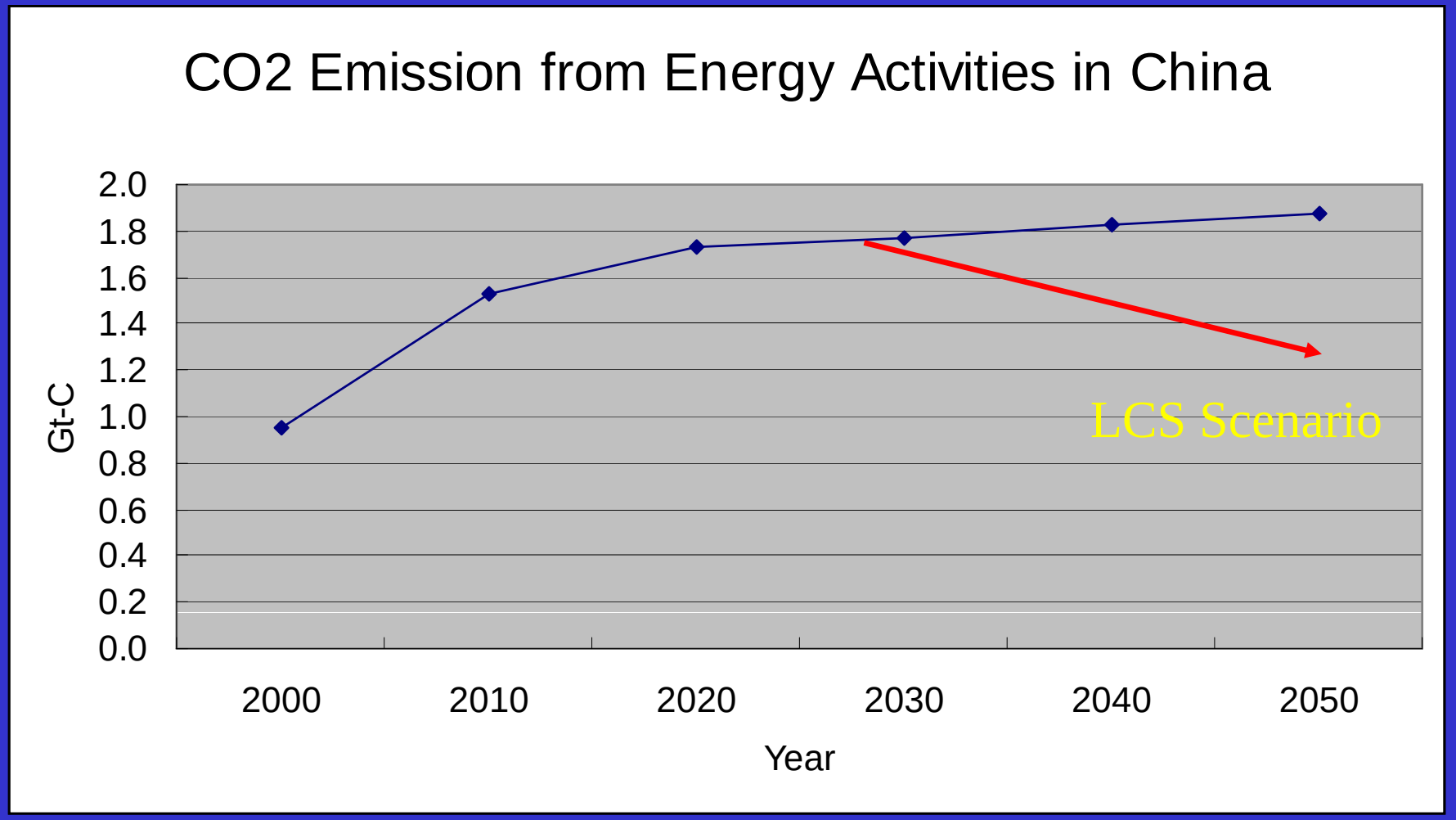
Target for Low Carbon Society

Shuzo Nishioka, Junichi Fujino;
NIES COP11 and COP/MOP1 side event
Global Challenges Toward
Low-Carbon Economy (LCE), Dec.3, 2005

Reduction Targets



web.mit.edu/globalchange/www/reports.html#pubs



Jiang Kejun (Energy Research Institute, China),
Low-Carbon Options in China
EMF 22, Tsukuba, Dec 12-14, 2006

Japan-UK Joint Research Project
LCS through Sustainable Development for Global Participation

The First workshop was held in Tokyo, June14-16, 2006.

Participants from 19 countries;
Asia: Japan, China, India, Thailand, Taiwan (China)
Africa: South Africa, Nigeria
Europe: UK, France, Germany, Denmark, Spain, Netherlands, Russia
Latin America: Brazil, Mexico, Chile
North America: US, Canada

G8 Gleneagles 2005

G8 Japan July 2008

The Second workshop was held in London, June13-15, 2007.

The Third workshop was held in Japan, Feb13-15, 2008.

Developing and Diffusing Innovations for our good life and LCS through SD

P.R. SHUKLA *et al.*, Low-carbon society scenarios for India, CLIMATE POLICY 8 (2008) S156–S176

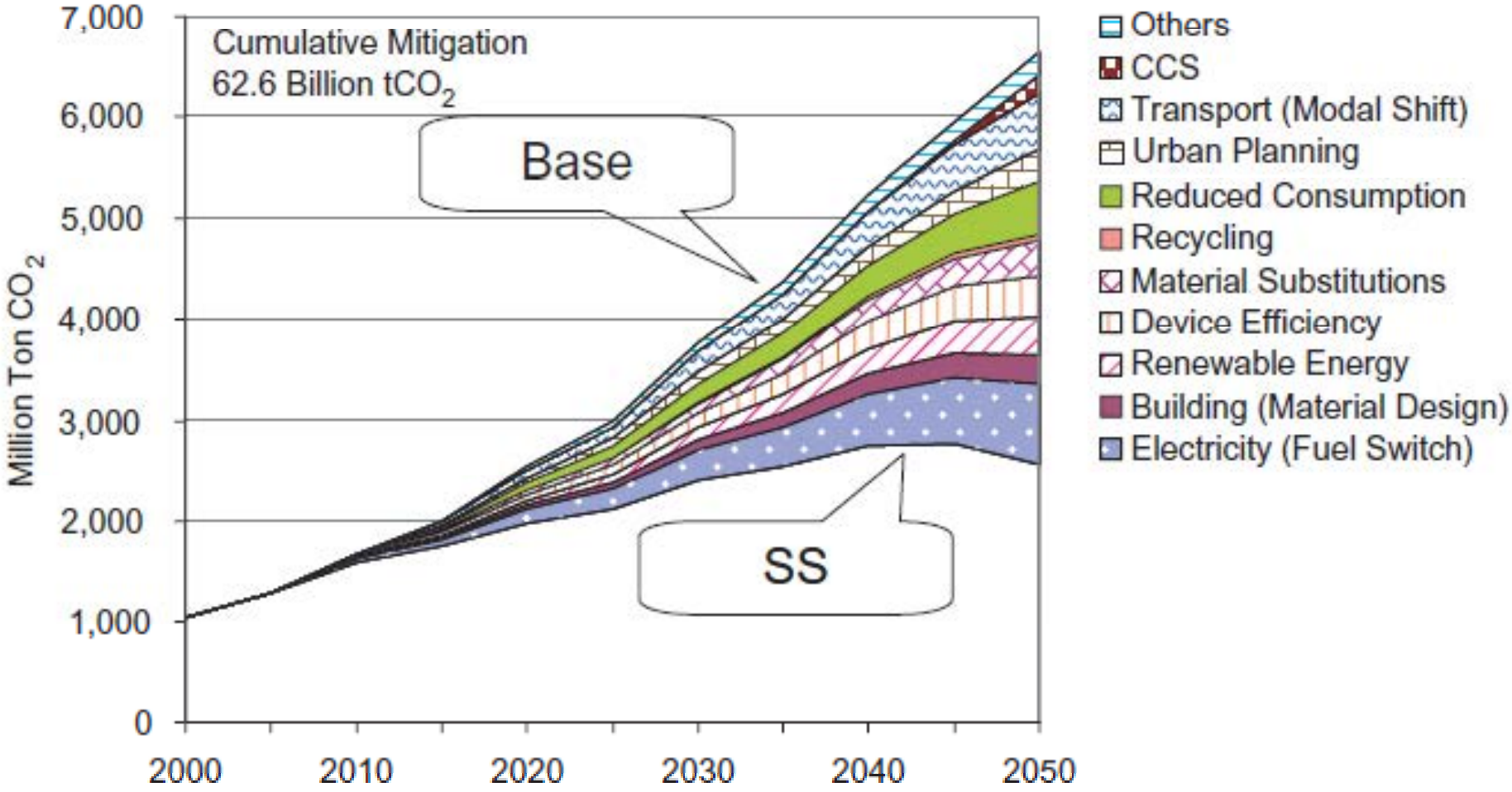
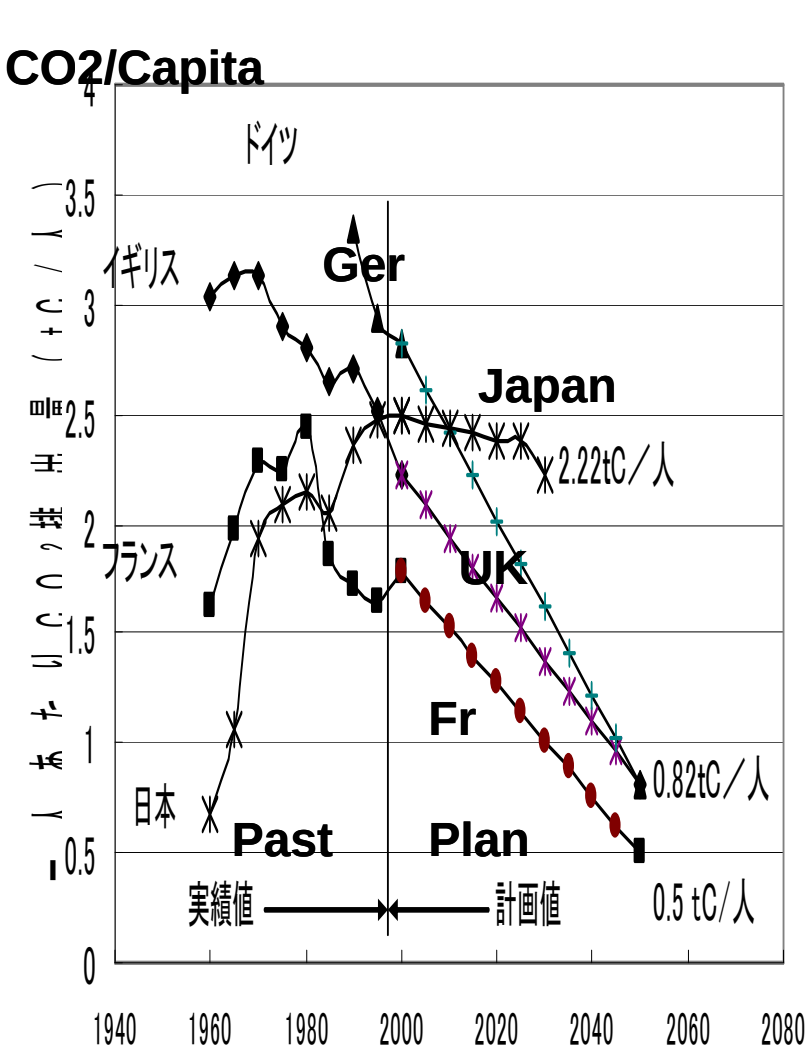
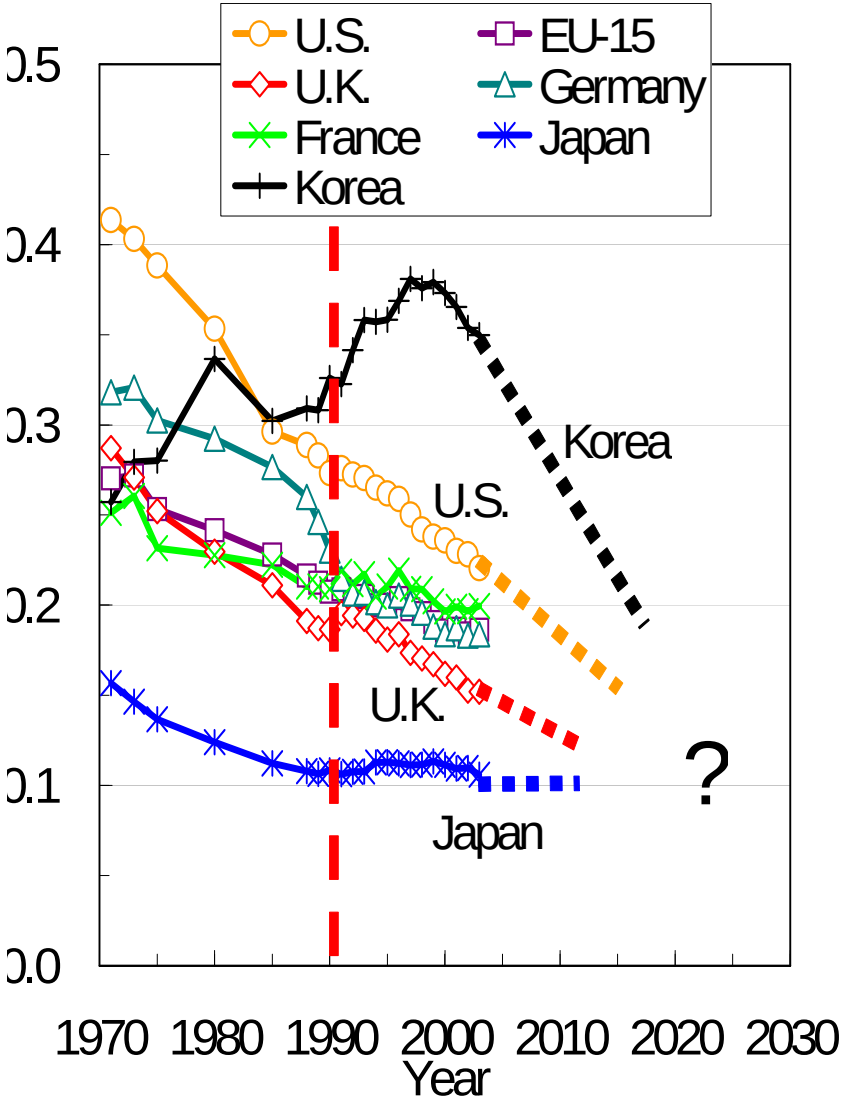


FIGURE 8 Mitigation options in the Sustainable society (SS) scenario.

Transition of energy intensity: Start of new innovation race





(Based on IEA Energy Statistics) By S.Nishioka and S.Ashina

LCS is not only to avoid dangerous climate change, but to…

- Avoid energy resource battles by using resources in efficient ways
- Develop many innovations to support global sustainable development
- Build safe and sound society considering appropriate land-use and city planning

We need good systems to pledge people's activity for LCS

LCS (Low-Carbon Society) is Risk Management

- We always face to risks if we are alive.
- Global warming is one of risks in our daily life, but it might become one of the huge/ biggest risks in some future…
- Short-term Sweet (Benefit) / Long-term Legality
- Market Failure -> Smart Regulation
- Crisis = 危(danger) + 機(chance)
- 創(create) 新(something new) = Innovation
- Sense of Urgency for Good Design of our Society

What gift can you provide for our future?

Christmas Concert of Yoko Fujino's Piano Class on Dec 23, 2005