Application of CGE model for national long-term scenario

Reina Kawase

Graduate School of Global Environmental Studies
Kyoto University

AIM CGE Workshop
7-11, November 2005
National Institute for Environmental Studies, Tsukuba

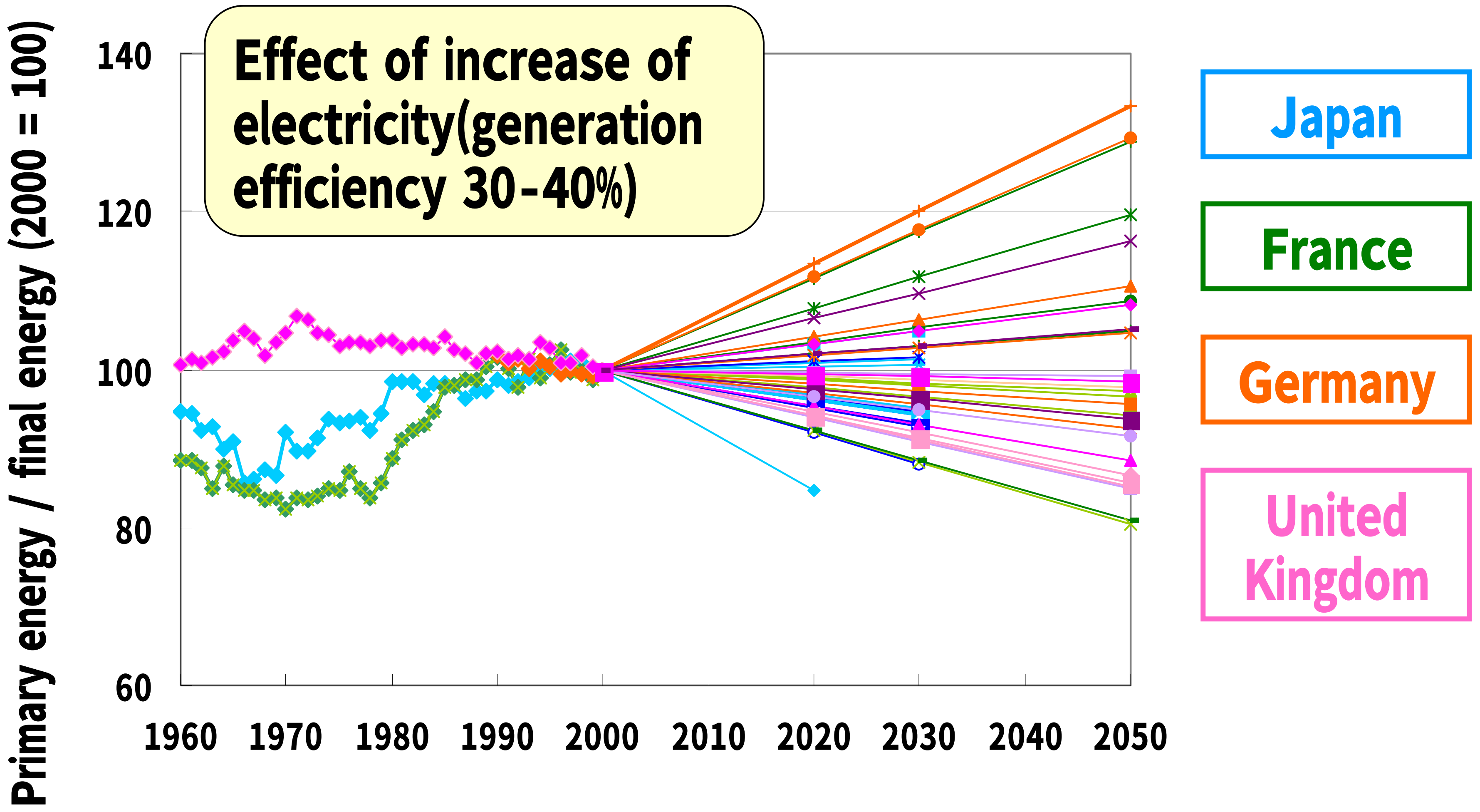
Contents

Purpose

- ∗ Application of CGE- model for developing national long-term scenarios

- ∗ By using outputs from CGE-model, what kind of analysis can we do?

Primary energy / final energy



Background of long-term scenarios

Tolerable temperature rise

↓

GHG concentration

↓

Global emission allowance

↓

Total national emission

↓

GHG emission reduction target toward 2050

1996 European Council

2 °C, CO_2 550 ppm

2005 "Avoiding Dangerous Climate Change"

2 °C, GHG 475 ppm

Approach

Contraction & Convergence

Brazilian approach

Multi stage *etc*

Reduction from 1990 level

Developed country: more than 50%

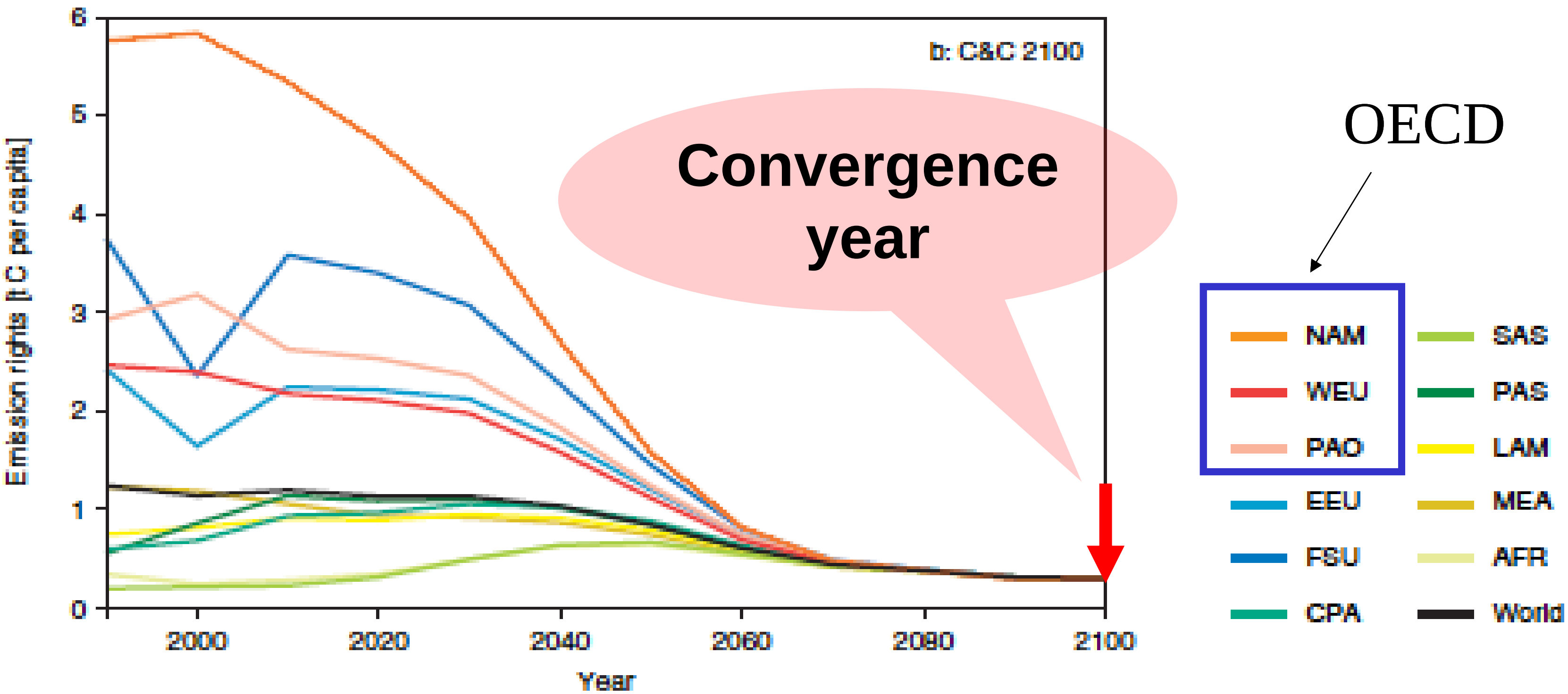
Developing country: ??

Allocating global emission

- Continuing Kyoto (pledge-based)
- Brazilian Proposal (Brazil /RIVM)
- Multi-criteria (CICERO)
- Multi-stage (RIVM)
- Contraction & Convergence (Global Commons Institute)
- Global Compromise - Preference Score (Benito Muller)
- Multi- Sector Convergence (ECN/CICERO)
- (global) Triptych approach (UU)
- Convergence in Emission-Intensities
- Emission intensity targets
- Growth cap index (Ellerman, MIT)
- Jacoby rule (MIT)
- Soft landing (IEPE)
- Sectoral commitments / sectoral CDM (Figueres)
- (sectoral) Technology standards (Barrett)
- Sustainable Policies and Measures (University of Cape town)

Allocating global emission (2)

Contraction & Convergence



Per capita emission is equally distributed after the convergence year among nations.

National Long-term CO_2 Emission Scenarios

Country	Agency	Model	Redction target of GHG emission	CO_2 emission from 2000
United Kingdom	DTI	bottom-up	CO_2: -60% from current level	-45, -60, -70%
Germany	Enquete Commission	bottom-up	GHG: -80% from 1990 level	-75%
France	MIES	--	CO_2 450ppm 0.5 tC /cap	-70%
Sweden	MOE	--	GHG 550ppm less than 4.5 tC/cap CO_2eq	about -50%
Netherlands	COOL project	--	CO_2 450ppm GHG: -80% from 1990 level	-75%
U.S.A	Hanson et al.	top-down	cap of annual emission decrease from 2010	-41～-46%
Canada	ETF project	--	--	-53%
Japan	Masui et al.	top-down	CO_2: -70〜80% from 1990 level	-72%
	JAIF	bottom-up	CO_2: -40% from 2010	-45%
China	Jiang et al.	bottom-up top-down	--	+60%
India	Nair et al.	bottom-up top-down	C conc. 550 ppm 650 ppm	+196% +266%

Classification of scenario

Purpose:

1) Set up the target such as stabilization level of GHG concentration and GHG emission reduction , and examine the pathway to achieve the target

2) Evaluate the effects and impacts of CO_2 emission reductions by introducing mitigation policy, assuming penetration of advanced technologies and the effects of socioeconomic transitions without GHG emission reduction targets

Feature:

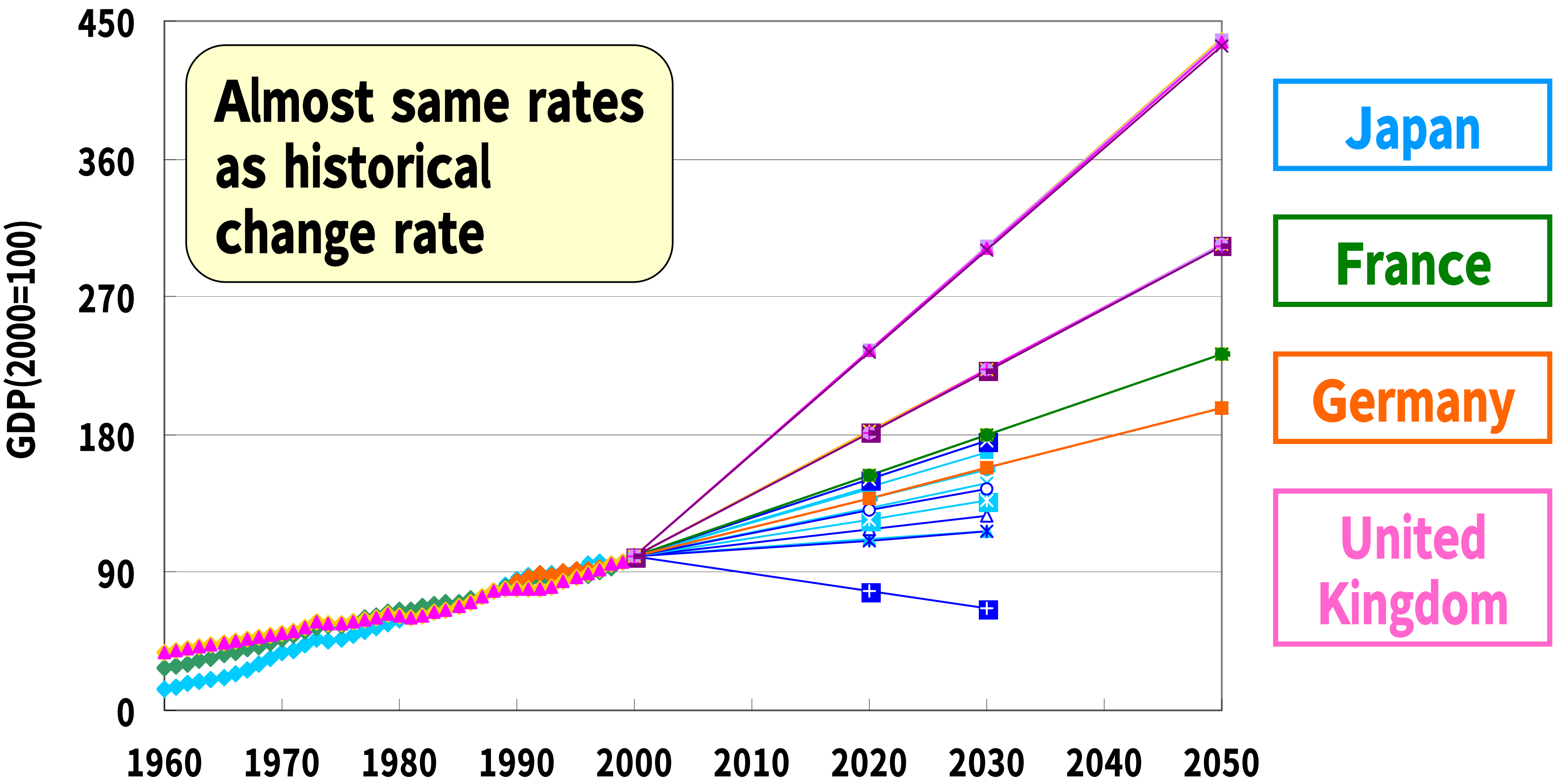
1) One future vision and changing only energy system to assess the pathway to achieve the target

2) Several future, check which future accepts which kind of options

Characters of Scenarios

Agency	Scenarios	Characters
Japan, Masui. et al	Reference (1)	W/o energy efficiency improvment, manufacturing to service
	Reference (2)	With energy efficiency improvement
	Reduction (1)	With energy efficiency improvement, low emission vehicles
	Reduction (2)	With energy efficiency improvement, introdutoin of biomass
France, MIES	w/o Eco	BaU
	Eco w/o fuel switching	Without fuel switching, with improved energy efficiency
	Supply	Involving a supply-driven response to climate change
	Gas turb	40% gas turbines share of electricity production
	F4 nuclear	Increased nuclear development
	F4 RCogN	Combing the use of nuclear, CHP, renewables
	F4 Sequestr	Maintaining large-scale fossil fuel use + CCS
	F4 w/o N+Seq	Abandoning nuclear power + CCS
	F4 H2	Hydrogen production network using nuclear power
Germany, Enquete Commission	Reference	Continuation of the current energy policy
	Efficient Conversion	Accelerated increase of fossil fuels use efficiency, CCS
	RES/EEU Initiative	Phased out of Nuclear power, promotion of renewables
	Fossil-Nuclear Energy Mix	Construction of new nuclear power stations after 2010
UK, DTI	Baseline45、60、70	Current values of society remain unchanged
	World Markets45、60、70	Globalisation , Scant regard for the global environment
	Global Sustainability45、60、70	Strong collective environmental action

GDP

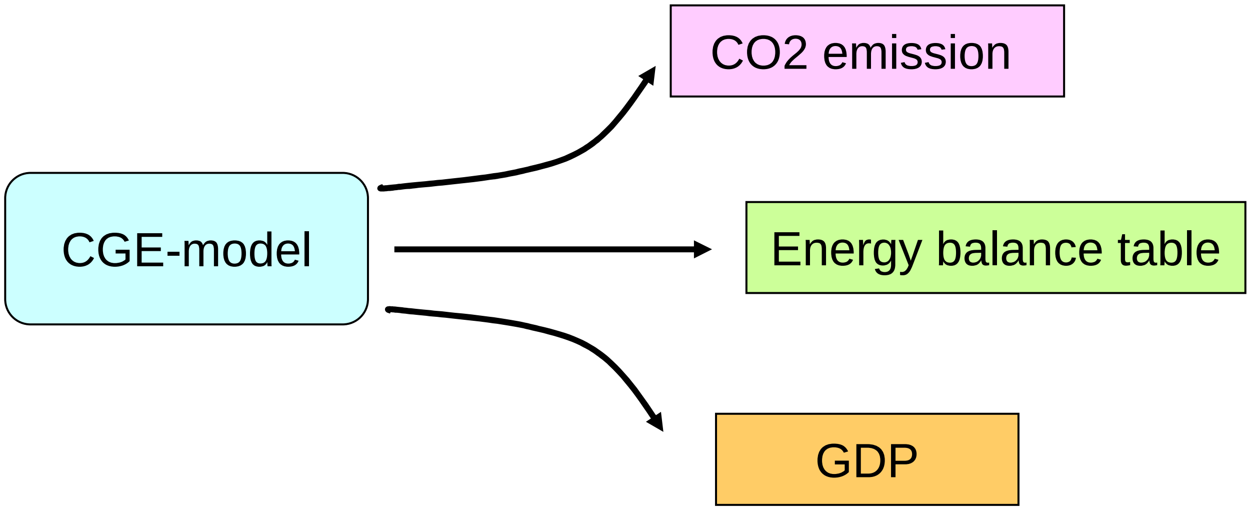


Almost same rates as historical change rate
GDP(2000=100)
450
360
270
180
90
0
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Japan
France
Germany
United Kingdom

Characters of Scenarios

CGE model can output main indicators, such as CO_2 emission, energy balance table by using sub module.

By using these data, we can analyze the factor of CO_2 emission change based on Kaya Identity.



Methodology

$$\sum_i C_i = \sum_i \frac{C_i}{CS_i} \cdot \frac{CS_i}{E} \cdot \frac{E}{A} \cdot A = \sum_i s_i \cdot i \cdot e_i \cdot A$$

$$\frac{\Delta C}{C} - \frac{\Delta A}{A} = \frac{\Delta s}{s} + \frac{\Delta i}{i} + \frac{\Delta e}{e}$$

CO_2 emission

GDP

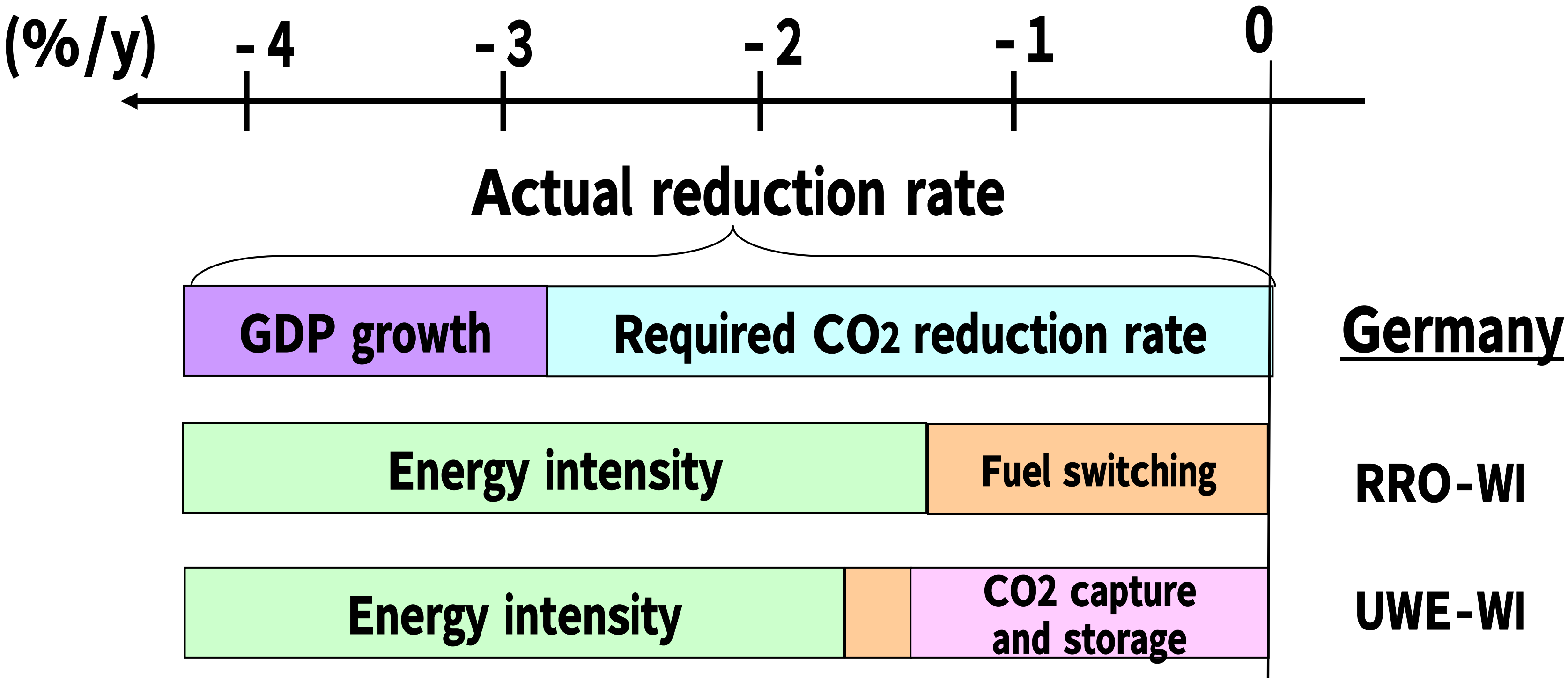
CCS

Carbon intensity

Energy intensity

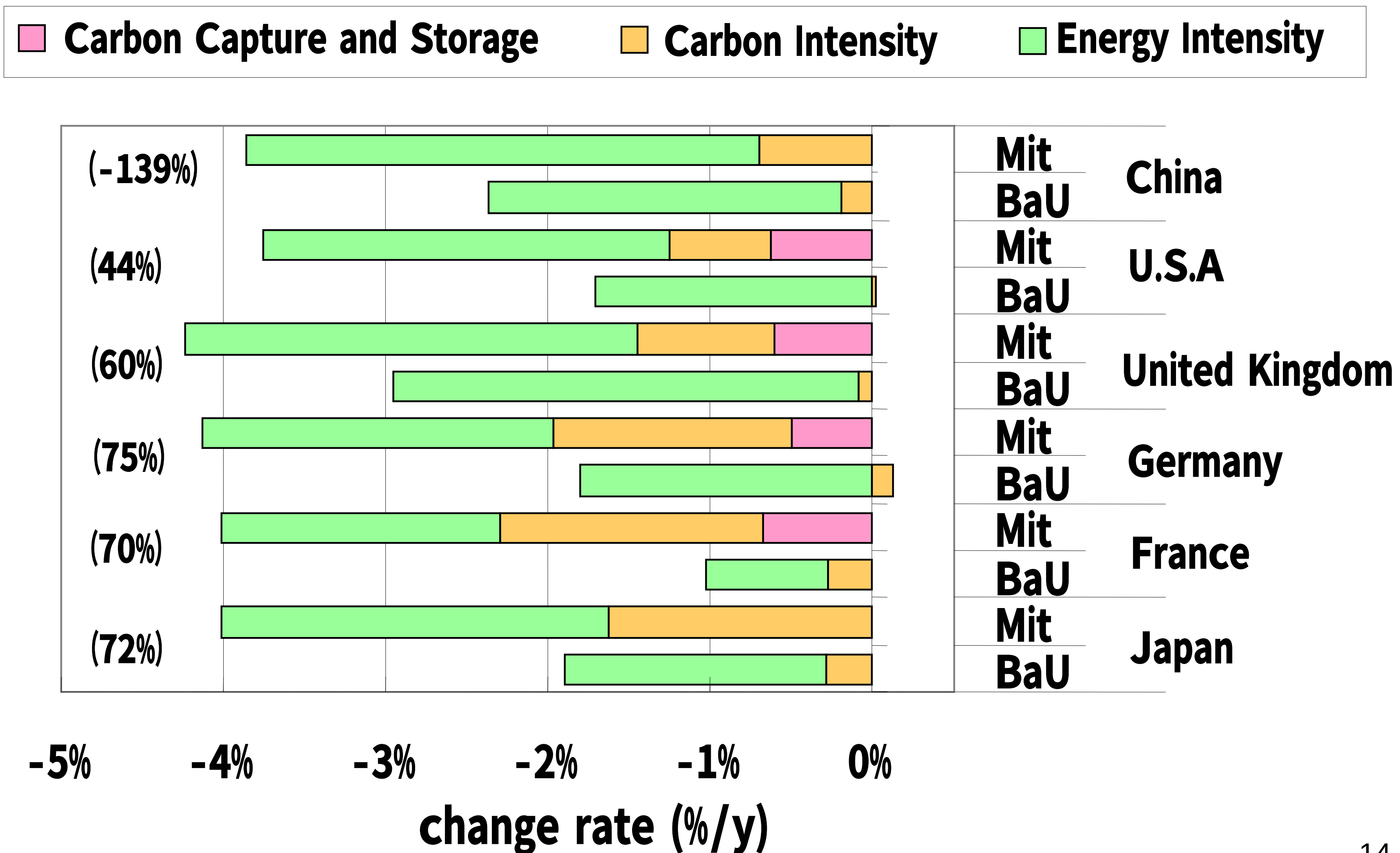
CO_2 emission is reduced by combining introduction of CCS, decrease of carbon intensity and improvement of energy intensity.

Outline of RBT

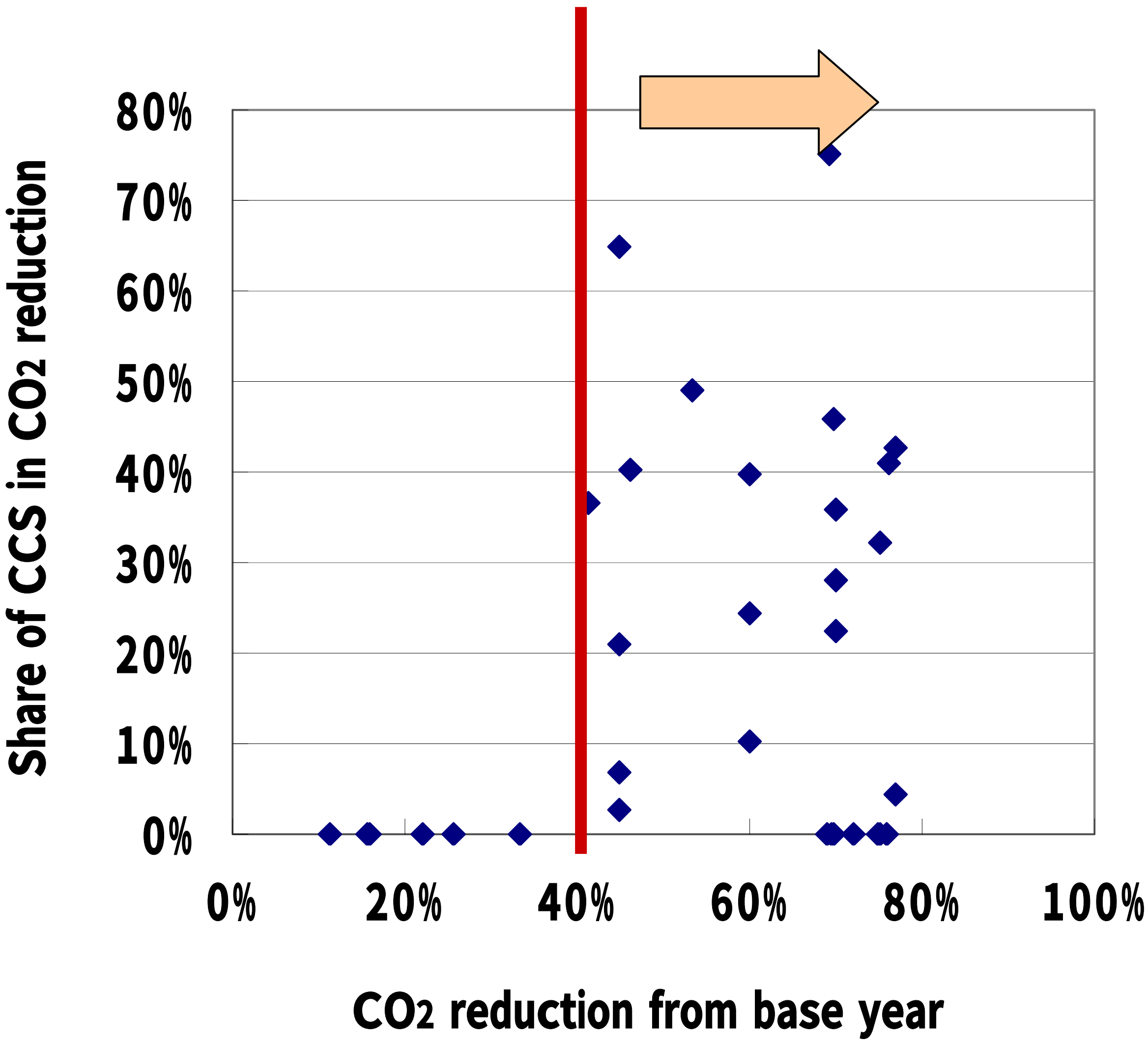


$$\frac{\Delta C}{C} - \frac{\Delta A}{A} = \frac{\Delta s}{s} + \frac{\Delta i}{i} + \frac{\Delta e}{e}$$

Decomposition of CO_2 emission change



CO_2 capture and storage



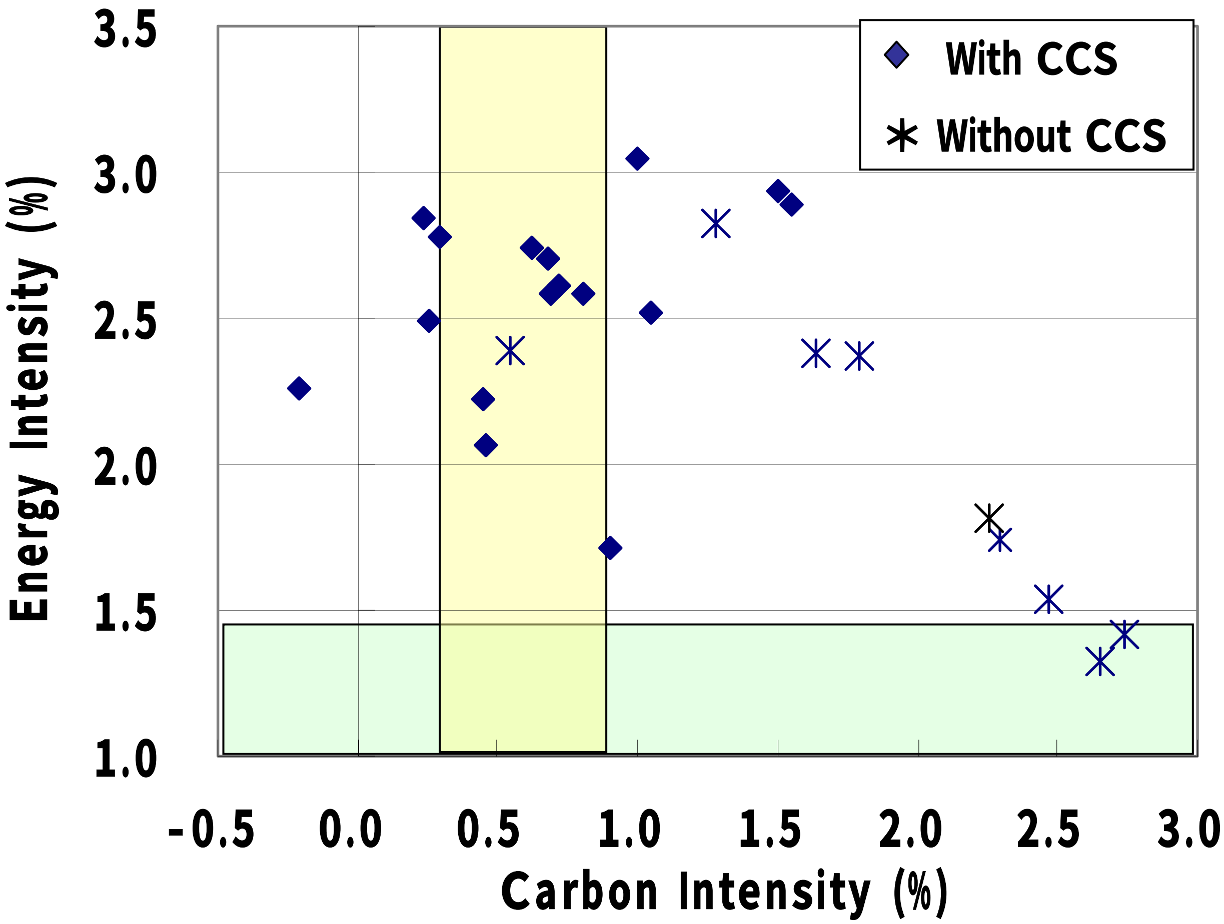
Reduction > 40%

↓

CCS introduction

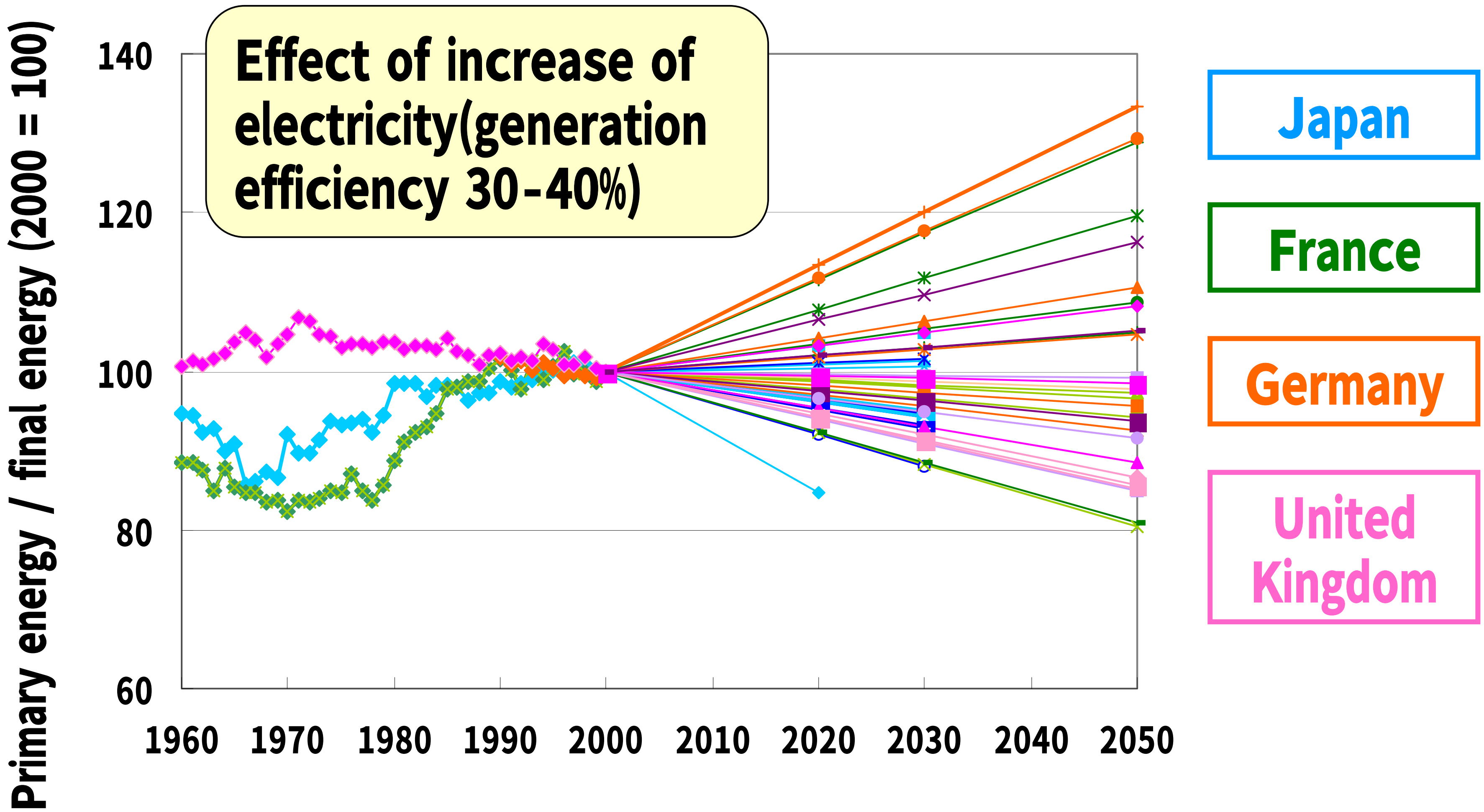
Considerable variation in the introduction rate of CCS

Energy intensity and Carbon intensity

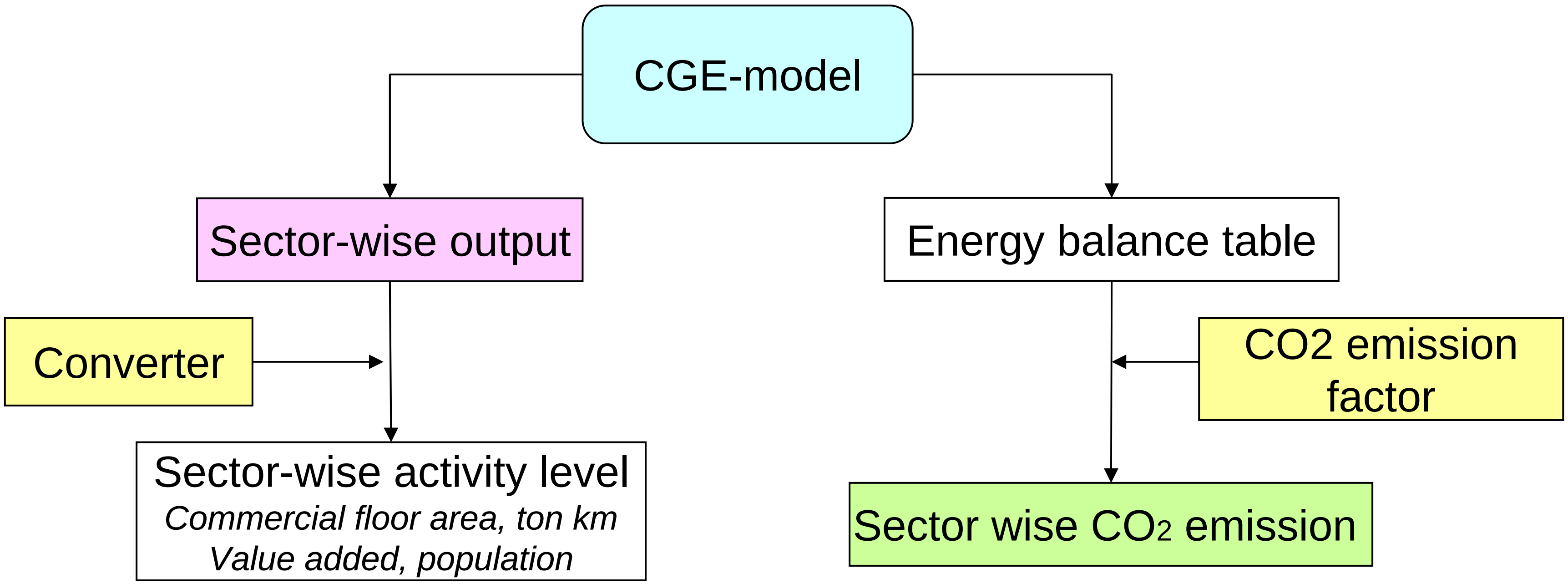


Carbon intensity and energy intensity will need to be improved by 2 - 3 times their historical levels in order to achieve the reduction targets.

Energy conversion efficiency



Sector-wise decomposition



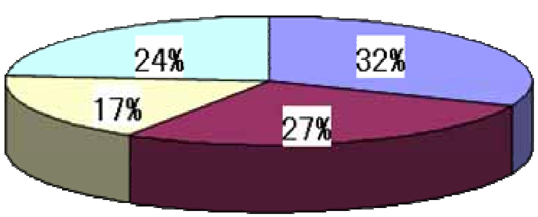
$$\sum_i C_i = \sum_k \sum_j \sum_i s_{j,k} \cdot c_j \cdot t_{j,k}^{-1} \cdot \delta_{j,k} \cdot e_{k,i} \cdot x_i \cdot D$$

Sector-wise analysis

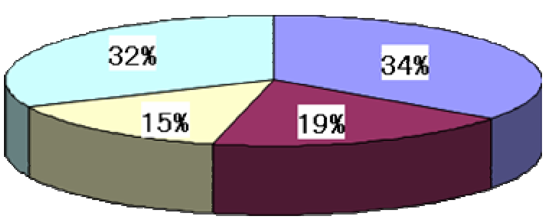
Table ： Sector-wise energy consumption and activity level

		IND	RES	COM	TRS	Total
UK	Energy	66	81	112	80	82
	Activity	119	161	151	164	347
Japan	Energy	74	97	148	86	89
	Activity	198	79	129	91	224
France	Energy	131	96		55	91
	Activity	182	164	269	232	232

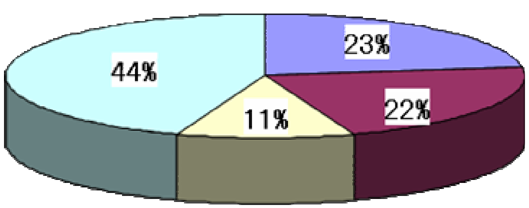
<UK>



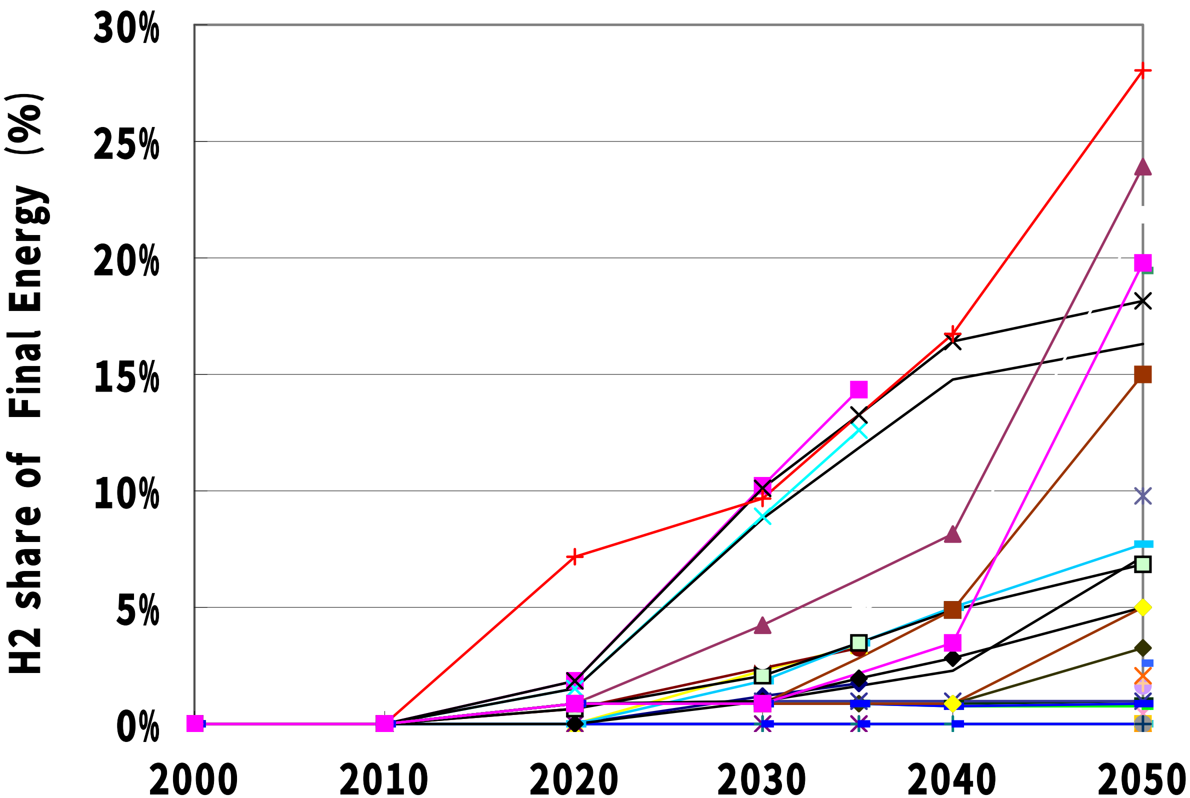
<Japan>



<France>



New energy : H2



The share will increase from around the year 2020.

The share of energy use in transportation sector in 2050.

WM60 (UK) = 59%,
Technology Drives the Market/CR(U.S.A.) = 18.2%

Summary

<Objectives>

- Application of CGE model for developing national long-term scenarios.
- Decomposed CO_2 emission changes

<Key findings>

1. Reducing CO_2 emissions by between 40% and 80% of their base year levels is set up as the goal of mitigation plans in developed countries. This requires reduction rate at the pace of about 4%/yr.
2. To achieve the target, energy intensity and carbon intensity must be improved at a pace of more than 2–3 times their historical change.
3. CCS is introduced in scenarios with CO_2 emission reduction by more than 40% and expected to contribute to between 0–75% of their reductions.
4. Introduction range of renewables and nuclear; range of renewables is 10–77% and that of nuclear is 0–65%.
5. From the sector-wise view point, reduction rates of the transport and industrial sectors are important.

Toward climate stabilization scenario

<Condition>

CO2 60% reduction

➔ –2.2%

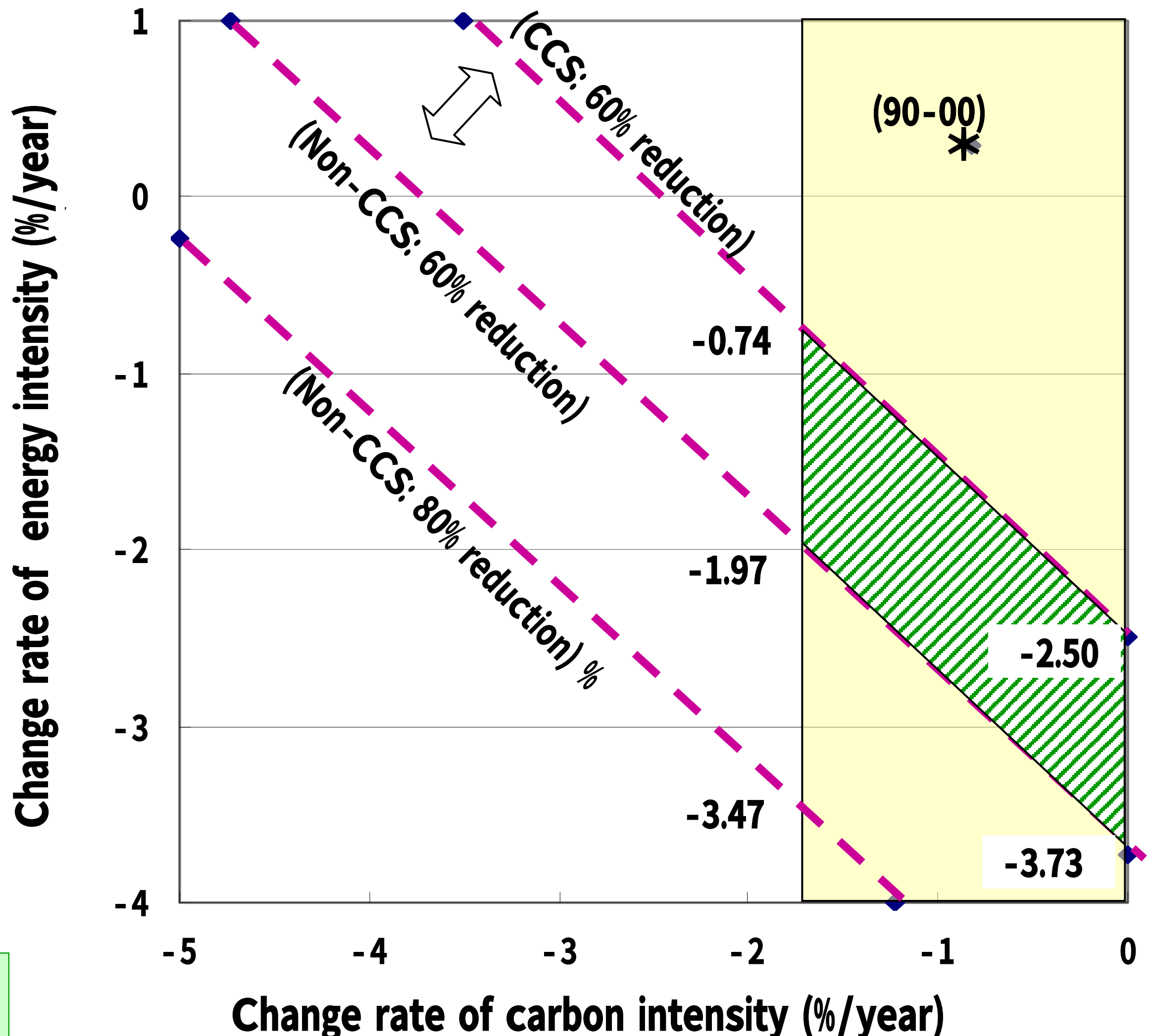
GDP growth: 1.53%

Maximum CCS: 1.23%

CI intensity: -1.76～0%

The combination of CI and EI must be set up within the slash zone.

$$\frac{\Delta C}{C} - \frac{\Delta A}{A} = \frac{\Delta s}{s} + \frac{\Delta i}{i} + \frac{\Delta e}{e}$$



Outline of RBT

Example of Result

Annual average change rate

Scenario	Change from base year (%)	Annual change rate (%/y)	Decomposition of CO_2 emission (%/y)					
			CO_2 capture and storage	Carbon Itensity	Conversion Efficiency	Energy Intensity	Activity	Residual
F4 Nuclear	-69.43	-2.34	-	-2.47	0.36	-1.90	1.70	-0.04
F4 RCogN	-69.75	-2.36	-	-2.29	0.17	-1.91	1.70	-0.03
F4 w/o N+Seq	-69.26	-2.33 =	-1.96	0.21	-0.42	-1.84	1.70	-0.03