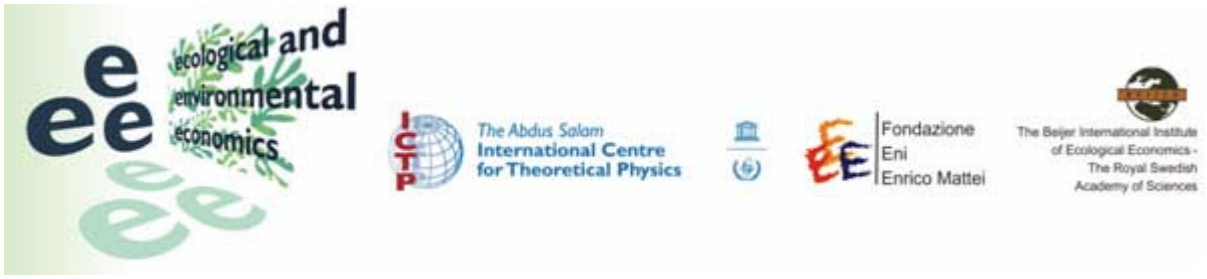


3rd International Workshop on

INTEGRATED CLIMATE MODELS:
AN INTERDISCIPLINARY ASSESSMENT OF
CLIMATE IMPACTS AND POLICIES

12-13 January 2006
ICTP, Trieste, Italy

GHG MITIGATION COST ANALYSIS IN WORLD REGIONS AND EVALUATION OF CLIMATE POLICIES - APPLICATION OF AIM

Tatsuya HANAOKA

National Institute for Environmental Studies - NIES
Japan

smr 1681

3rd Int'l WS on Integrated Climate Models
ICTP, Trieste, Italy
12-13, January, 2006

GHG mitigation cost analysis in world regions and evaluation of climate policies - Application of AIM

Mikiko KAINUMA
Toshihiko MASUI
Junichi FUJINO
Tatsuya HANAOKA
Hideo HARASAWA
Kiyoshi TAKAHASHI
Yasuaki HIJIOKA
National Institute for Environmental Studies

Yuzuru MATSUOKA
Reina KAWASE
Kyoto University

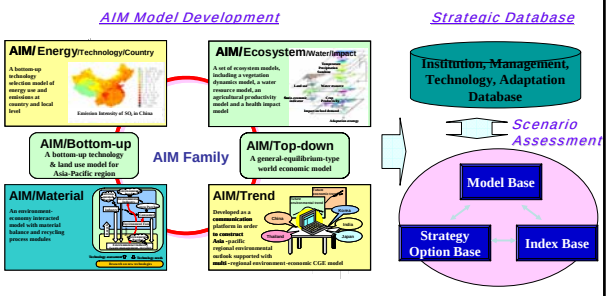
Outline of Presentation

1. Overview of AIM model family
2. Current major projects in AIM team
3. Example of Global analyses
   - ✓ Evaluation of climate policies
     - application of AIM/Impact[Policy]
   - ✓ GHG mitigation cost analysis in world regions
     - application of AIM/Enduse[Global]

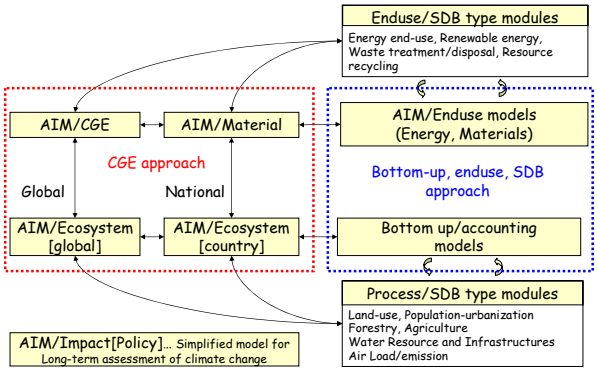
Appendix
- ✓ Japan low carbon society scenarios toward 2050

AIM team activities

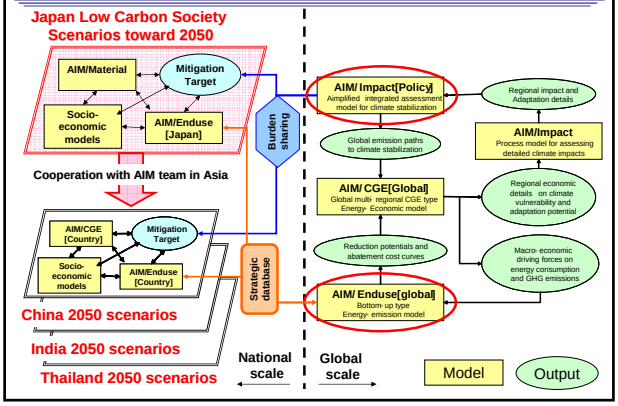
AIM = Asia-Pacific Integrated Model



Overview of AIM family



Current Major Projects in AIM team



Evaluation of climate policies: assessment of emission permit paths & timing of GHG reduction policies

- Application of AIM/Impact[Policy] -

AIM/Impact[Policy]

AIM/Impact[Policy] is a policy support tool, for use in comprehensive anaysis and assessment of:

- **global warming control targets (such as stabilization of GHG concentrations)**
- **economically efficient emissions paths to realizing these targets**
- **consequent impacts and risks of these targets.**

The purpose of developing AIM/Impact[Policy] are:

(1) **To create a comprehensive platform for global warming impact studies** in various sectors on a national scale for a wide-range of GHG stabilization targets

(2) **To create a platform incorporating flexibility schemes and burden sharing among countries** for investigating the establishment of climate stabilization targets for GHG emissions reduction plans

Purpose of this study

1. **To project the optimal GHG emissions path** and **assess the timing of GHG reduction policies**, under GHG stabilization constraints

2. **To show the scale of the global warming impact under the optimal GHG emissions path**, and provide data for investigating whether or not established future targets are sufficient to avoid "dangerous impacts" (validity of future targets)

Structure of AIM/Impact[Policy]

- **AIM/Impact[Policy]** consists of two major parts:
  - **GHG emissions projection**
  - **Climate change impacts projection**

➢ **The GHG emission projection part** consists of two linked models and two linked scheme:

(1) **Energy economic model** to project global GHG emission paths under various constraints

(2) **Burden sharing scheme** to calculate the reduction burden by country

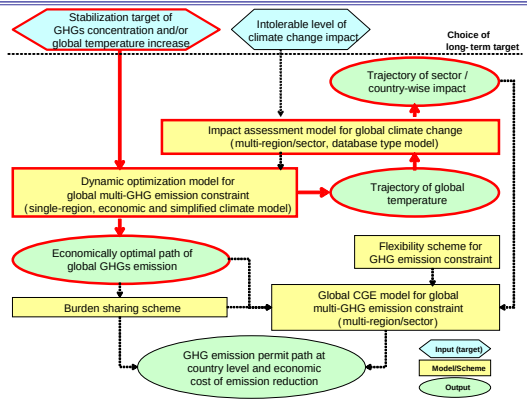
(3) **Global CGE model** to assess economic impacts resulting from the GHG reduction burden of each country

(4) **Flexibility scheme** (e.g. emission trading, CDM, etc.)

➢ **The climate change impacts projection part** consists of one model:

(1) **impact assessment model** for climate change under the optimal emissions paths

Structure of AIM/Impact[Policy]

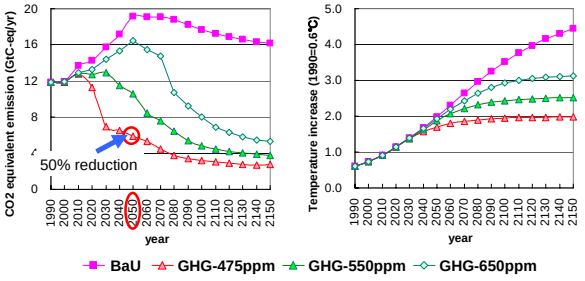


Outline of model simulation

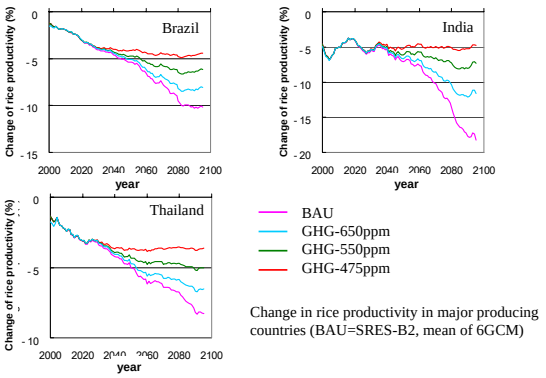
- Baseline Scenario: **SRES B2**
- Discount rate: **4%**
- Climate sensitivity: **2.6℃**
- Simulation cases
  - ✓ **Business as Usual**
  - ✓ **GHG-475ppmv**: 475 ppmv cap on CO2 concentration
  - ✓ **GHG-550ppmv**: 550 ppmv cap on total GHG concentration
  - ✓ **GHG-650ppmv**: 650 ppmv cap on total GHG concentration

Simulation Results ①

- To achieve 2℃ temperature increase in 2150, **475ppmv cap on total GHG constraint is required**
- Reduction required to achieve 475ppmv cap on total GHG constraint: **3.0 Gt-Ceq/yr** in 2020 and **13.3 Gt-Ceq/yr** in 2050



Simulation Results ②



Change in rice productivity in major producing countries (BAU=SRES-B2, mean of 6GCM)

Findings

1. To avoid average global temperature increases above 2°C, a stabilization target for GHG concentrations of less than 475 ppmv is needed.
2. With regard to the timing of GHG reduction policies, to achieve this broad-based target, early actions on emissions reductions are necessary in the near future.

Remaining issues

1. Uncertainty of climate sensitivity
   These results are based on the climate sensitivity of 2.6 ℃, so the uncertainty of climate sensitivity should be considered.
2. Upgrade of the energy economic model
   - from a single global model to multi-regional global model
   - the various factors more closely reflect reality
     => improve the accuracy of the simulation.
3. Cost analysis
   Although AIM/Impact [Policy] includes the economic model, the cost involved in achieving the target was not assessed yet. It is bacause the countermeasures to reduce GHG emissions have not been described sufficiently in the present economic model.

GHG mitigation cost analysis in world regions

- Application of AIM/Enduse[Global] -

Purpose of this study

1. **To estimate marginal abatement costs and evaluate GHG mitigation potentials** in world regions in 2020.
   - **Region-wise** mitigation potentials and costs
   - **Sector-wise** mitigation potentials and costs
2. To analyze possibility of achievement of required reduction under stabilization constraints

Framework of AIM/Enduse[Global]

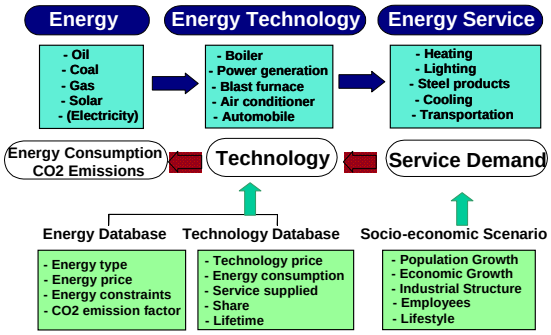
Type : a Bottom-up optimization model with detail technology selection framework
Target Regions : 21 geographical world regions
Target Gas :CO2, N2O, CH4, HFCs, PFCs, SF6
Target Sectors : multiple sectors
- **Power generation sector**
- **Industry sector**
- **Residential sector**
- **Commercial sector**
- **Transport sector**
- **Agriculture sector**
- **CH4 & N2O emissions sector**
- **F-gas emissions sector**

Geographical coverage

Region	Code
1) Japan	JPN
2) China	CHN
3) India	IND
4) Indonesia	IDN
5) Korea	KOR
6) Thailand	THA
7) Other South-east Asia	XSE
8) Other South Asia	XSA
9) Middle East	XME
10) Australia	AUS
11) New Zealand	NZL
12) Canada	CAN
13) USA	USA
14) EU-15 in Western Europe	XE15
15) EU-10 in Eastern Europe	XE10
16) Russia	RUS
17) Argentine	ARG
18) Brazil	BRZ
19) Other Latin America	XLM
20) Africa	XAF
21) Rest of the World	XRW

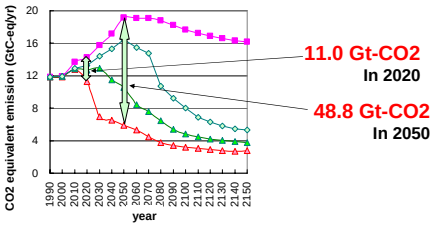
Asia regions in detail

Frame of the AIM/Enduse Model



How much emissions should be reduced in 2020?

- To avoid average global temperature increase above 2℃, it is necessary to achieve GHG concentrations of less that 475ppmv
- Reduction required to achieve 475pmv cap is 11.0 Gt-CO2eq/yr in 2020 and 48.8 Gt-Ceq/yr in 2050



Note) Calculated by AIM/Impact[Policy]

How much reduction could be possible?

- ✓ Required reduction to achieve 475ppmv-CO2eq (multi-gas) constraint:
  11.0 Gt-CO2eq in 2020
- ✓ Global reduction potential in 2020:
  4.5 - 7.2 Gt-CO2eq in no-regret case
  7.7 - 11.3 Gt-CO2eq under 100 US$/t-CO2 marginal costs
- ✓ Regional reduction potential in 2020 (5% discount rate) :
  in no-regret case:
  2.1 Gt-CO2eq and 5.0 Gt-CO2eq
  under 100 US$/t-CO2 marginal abatement costs:
  3.4 Gt-CO2eq and 7.9 Gt-CO2eq
  in developed countries and developing/transition economies, respectively

Outline of model simulation

- Target Year: **2020**
- Discount rate:
  (1) **5% (private & public sectors)**
  (2) **33%(private sectors), 10% (public sectors)**
- Simulation cases
  - ✓ **Reference case (technology-frozen case)**
    i.e.) the case under existing technology options with the same technical and economic characteristics as in 2000
  - ✓ **Advanced technologies case**
    i.e.) the market selections of realistic advanced technologies

Reduction potentials and abatement costs

Reduction potentials in 2020

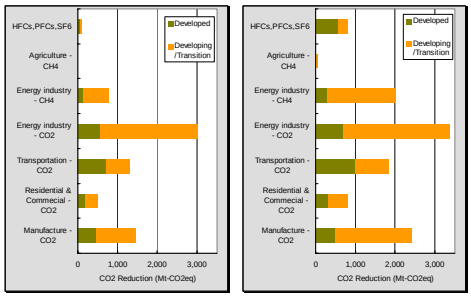
Mt-CO2

Discount rate		5%			33%(Private), 10%(Public)		
Marginal abatement cost 2000US$		< 0	< 100	< 300	< 0	< 100	< 300
CO2	Steel	395	571	642	338	486	546
	Other manufacture	1,045	1,850	1,855	196	1,195	1,898
	Indutry total	1,440	2,421	2,496	533	1,682	2,444
	Residential	210	330	351	22	110	281
	Commercial	307	474	483	56	275	373
	Transportation	1,298	1,826	2,481	448	542	1,233
	Agriculture	0	0	0	0	0	0
	Others	0	0	0	0	0	0
	Power generation	3,026	3,366	3,526	3,010	3,082	3,463
	Total	6,282	8,417	9,337	4,069	5,690	7,795
CH4	Agriculture	0	42	330	0	32	152
	Energy	797	2,005	2,005	478	2,001	2,005
	Total	797	2,048	2,335	478	2,033	2,158
N2O		-	-	-	-	-	-
HFCs,PFCs,SF6 (4%)		84	796	859	-	-	-
Total		7,163	11,260	12,531	4,548	7,723	9,953

in the year 2020

Regional Reduction potentials

Discount rate = 5%



< US$ 0, 2020

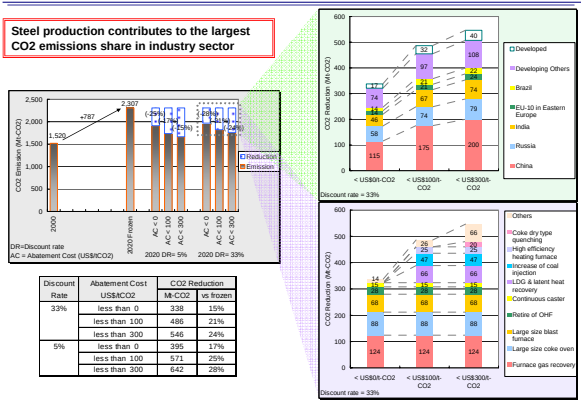
2.1 Gt-CO2 and 5.0 Gt-CO2
(Developed and Developing/Transition)

< US$ 100, 2020

3.4 Gt-CO2 and 7.9 Gt-CO2
(Developed and Developing/Transition)

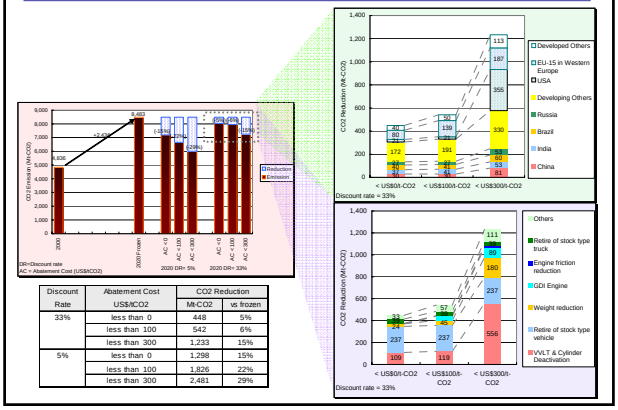
Reduction potentials in steel sector in 2020

Steel production contributes to the largest CO2 emissions share in industry sector



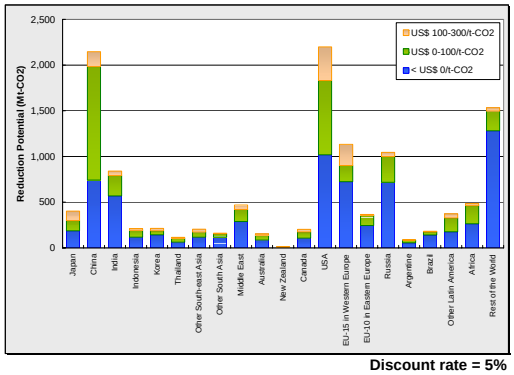
Discount Rate	Abatement Cost US$/tCO2	CO2 Reduction Mt-CO2	CO2 Reduction vs frozen
33%	less than 0	338	15%
	less than 100	486	21%
	less than 300	546	24%
5%	less than 0	395	17%
	less than 100	571	25%
	less than 300	642	28%

Reduction potentials in transport sector in 2020



Discount Rate	Abatement Cost US$/tCO2	CO2 Reduction Mt-CO2	CO2 Reduction vs frozen
33%	less than 0	448	5%
	less than 100	542	6%
	less than 300	1,233	15%
5%	less than 0	1,298	15%
	less than 100	1,826	22%
	less than 300	2,481	29%

Region-wise reduction potentials in 2020



Discount rate = 5%

Technology with large reduction potentials

under 100 US$ marginal abatement costs in 2020

Developed	(MtCO2)	Developing/Transition	(MtCO2)
High efficiency gasoline engine (VVLT, GDI etc)	632	Existing type of power plant (coal ,gas)	2,462
Existing type of power plant (coal ,gas)	546	Use of instrument air, low bleed pneumatic devices*	676
Inverter control for motor	216	Gas high efficiency industrial furnace	449
Fluorescent of incandescent type	143	Inverter control for motor	431
Domestic refrigeration: recovery	129	Coal bed methane ventilation oxidizer for heat**	232

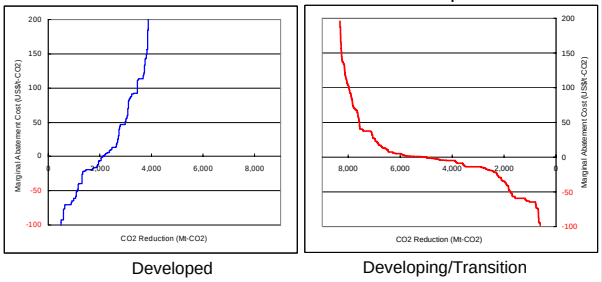
*** Recovery of CH4 leakage from natural gas pipeline and well**
**** Recovery of CH4 in coal mine**

(Discount rate = 5%)

Marginal abatement cost of developed and developing countries in 2020

(Discount rate = 5%)

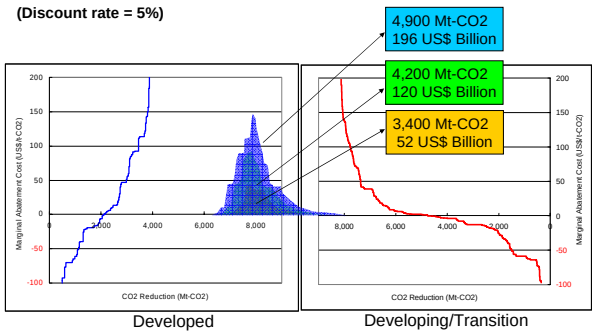
left-right reversal



Developed

Developing/Transition

Marginal abatement cost of developed and developing/transition economies



Findings

1. Reductions of 7.2 Gt-CO2eq in no-regret case and 11.3 Gt-CO2eq under 100 US$/t-CO2 marginal abatement costs in 2020 with a 5% discount rate are possible, if we move into action and take countermeasures right now.

2. Reduction potential in developed countries under 100 US$/t-CO2 in 2020 with a 5% discount rate is 3.4 Gt-CO2, which is less than required reduction to achieve 475ppmv-CO2eq (multi-gas).

3. International cooperation play an important role to reduce world GHG emissions. It is essential to set up frameworks considering transfers of technologies and financial aid to the developing regions.

Remaining issues

1. Update of database such as new advanced technologies, grass-roots countermeasures, etc

   This analysis was based on realistic technologies with current cost estimates. Therefore, it may be possible to reduce more if new advanced technologies become available in the future.

2. Future scenarios and exogenous determination of service demands of enduse services

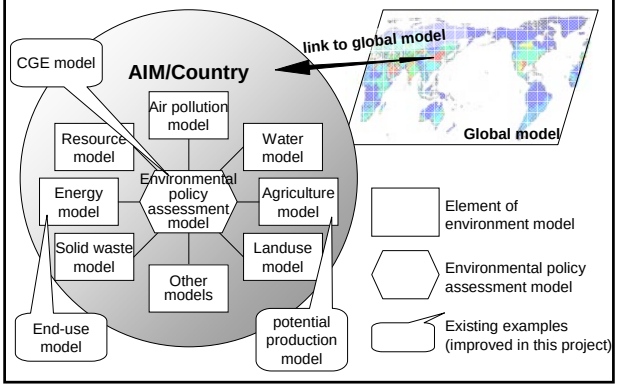
3. Hard-link among sector models

On-going AIM activities

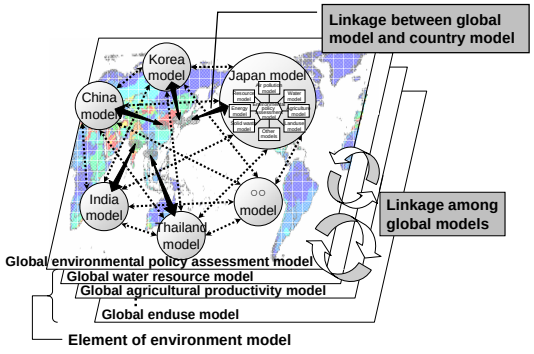
- Development/Upgrade of country models
- Development/Upgrade of global models
- Hard-link/Soft-link among relative models/modules
- Cooperation with Asia-Pacific countries for scenario development

and so on

Development of country model



Development of global model



Thank you!

Further Information

http://www-iam.nies.go.jp/aim/index.htm

Appendix

Japan Low Carbon Society Scenario toward 2050

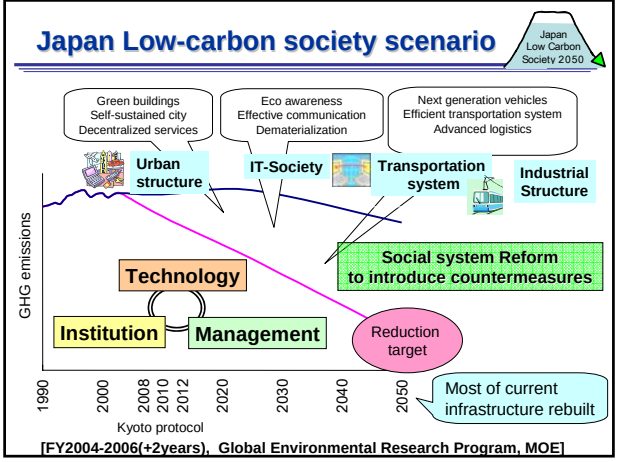
Background

- This project is supported by Ministry of Environment in Japan.
- This project consists of 6 teams:
  - **Scenario team**
  - Urban structure team
  - Industrial structure team
  - Transportation system team
  - IT-society team.
  - Target criteria team

Purpose of this study

1. To set GHG reduction targets in Japan from the long term perspective
2. To build future visions of Japan Low-carbon society 2050
3. To propose GHG reduction policy to realize low-carbon society in Japan

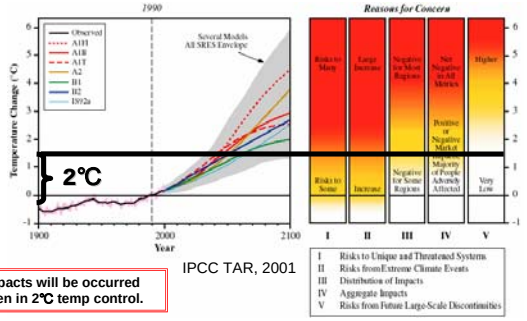
Japan Low-carbon society scenario



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

Where is the stabilization target level?

To avoid serious Climate Change impacts, it is necessary to stabilize temperature raise below 2 degree compared with pre-industrialized level

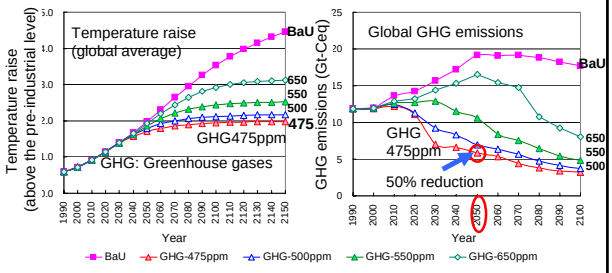


IPCC TAR, 2001

Impacts will be occurred even in 2℃ temp control.

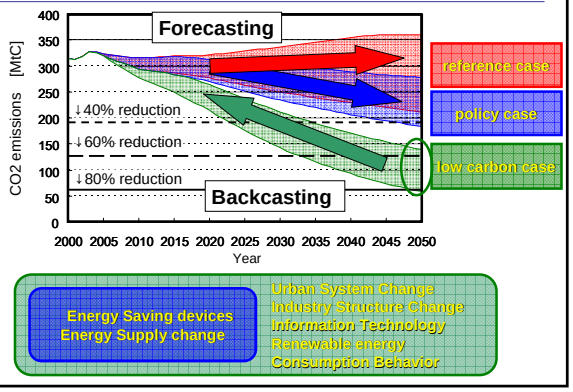
How much reduction is required?

- **Around 50% reductions in 2050 are required to achieve 475ppmv cap on total GHG constraint compared to 1990 emission level**
- **Japan may be required more reduction (60-80%).** Another country-wise 2050 scenarios have been studied (UK 60%, Germany 80%, France 75%, etc).

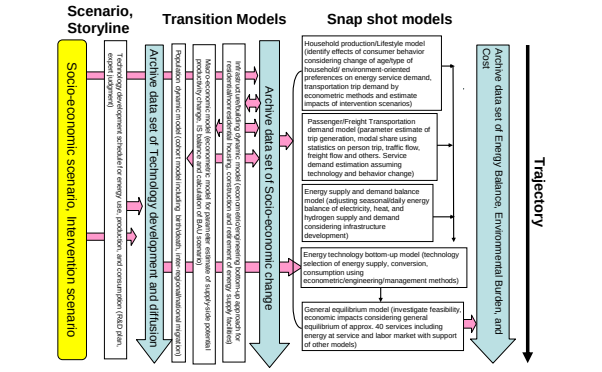


Note) Calculated by AIM/Impact[policy]

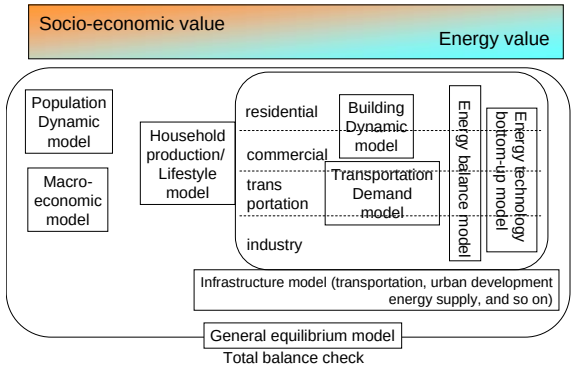
Reduction Paths toward Low Carbon Society



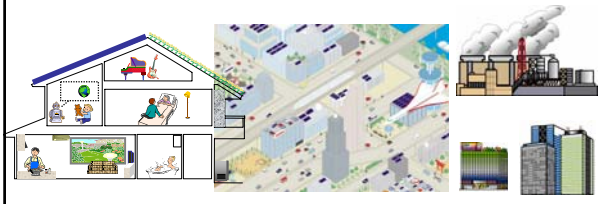
Models for scenario development



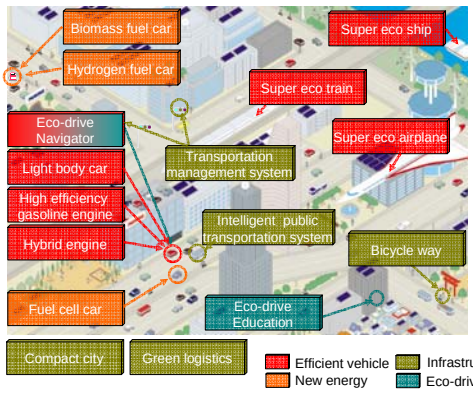
Models for scenario development



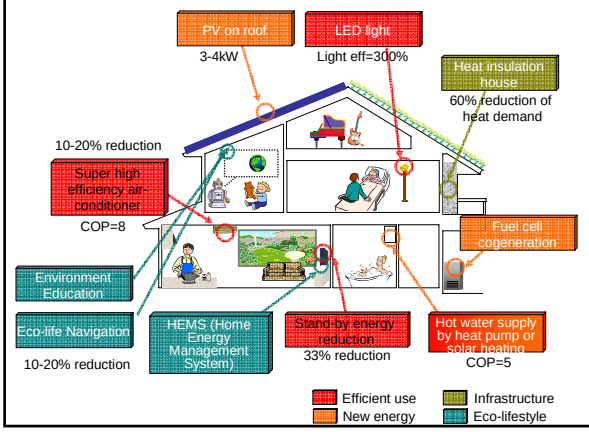
Snapshot of 2050 Japan - 70% reduction scenario -



2050 Transportation



2050 Residential



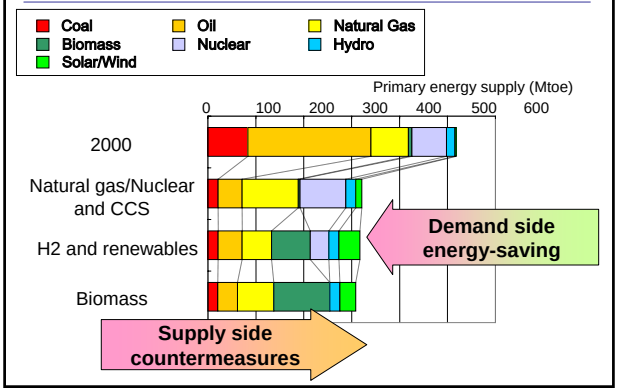
Energy supply scenario

1.Natural gas/Nuclear and CCS scenario
- Nuclear energy in electricity mix increase (50%)
- FCV diffusion (100%)
- H2 production by natural gas with CCS

2.H2 and renewables scenario
- No additional nuclear plant (max lifetime = 60yrs)
- FCV diffusion (100%)
- H2 production by biomass and wind
- biomass energy import

3.Biomass scenario
- Nuclear phase-out
- No H2, bio-fuel+hybrid
- large amount of biomass energy import

Preliminary calculation for primary energy mix to achieve 70% CO2 reductions in 2050



Key messages

Japan Low Carbon Society 2050

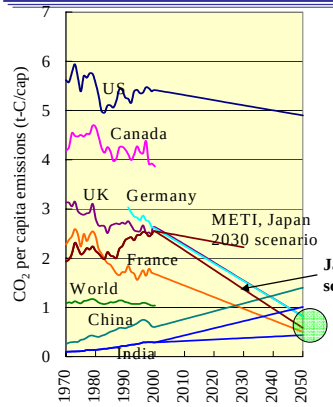
1. **Large amount of GHG reductions are required**
   It is estimated that around 50% GHG reductions in 2050 are required to control temperature raise below 2C.

2. **Both supply-side and demand-side reductions are required**
   Well mix of technology development, diffusion of GHG reduction options by behaviors, institutions which help GHG reduction

3. **It's time to action. It takes time to change social system, infrastructure…**
   Our experience can apply to Asia-Pacific countries.

COP11/MOP1 side event

Japan Low Carbon Society 2050



Current per capita CO_2 emissions and Target

Japan 2050 scenario

Target for Low Carbon Economy