Projection of GHG emissions

Make the inventory and AIM models will give the future pathways

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The 7th Workshop on GHG Inventories in Asia (WGIA7)
7-10 July 2009, Seoul, Republic of Korea

Agenda

1. Overview of AIM Project: *Who am I?*
2. Two approaches for Projection: *Top-down and Bottom-up*
3. Lead the way by setting an inventory: *Why is the WGIA important?*
4. Examples of Projection by using AIM/ESS: *How do we project?*
5. Make a step forward: *What's next?*

INTRODUCTION OF AIM

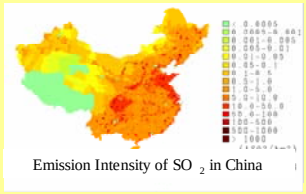
Overview of AIM Project (1/2)
AIM is Integrated Assessment Model

AIM: Asia-Pacific Integrated Model

AIM Model Development

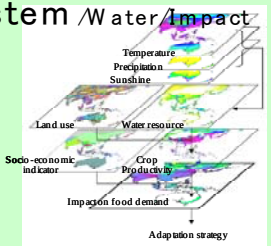
AIM/Energy/Technology/Country

A bottom-up technology selection model of energy use and emissions at country and local level



AIM/Ecosystem/Water/Impact

A set of ecosystem models, including a vegetation dynamics model, a water resource model, an agricultural productivity model and a health impact model



AIM/Bottom-up

A bottom-up technology & land use model for Asia-Pacific region

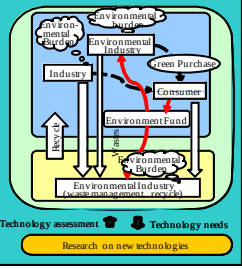
AIM Family

AIM/Top-down

A general-equilibrium-type world economic model

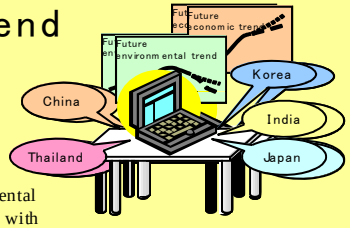
AIM/Material

An environment-economy interacted model with material balance and recycling process modules



AIM/Trend

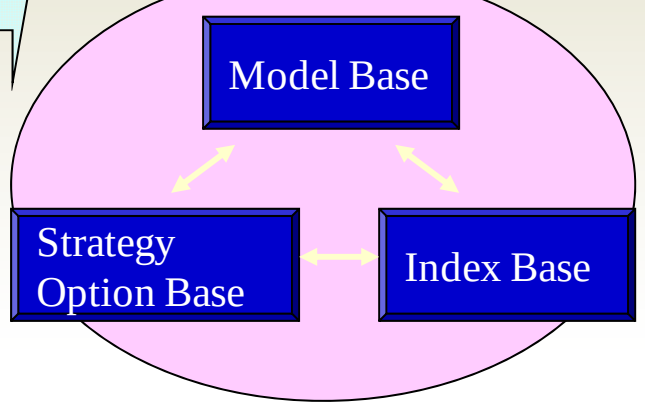
Developed as a **communication** platform in order **to construct** **Asia**-pacific regional environmental outlook supported with **multi**-regional environment -economic CGE model



Strategic Database

Institution, Management, Technology, Adaptation Database

Scenario Assessment



AIM Website: http://www-iam.nies.go.jp/aim/

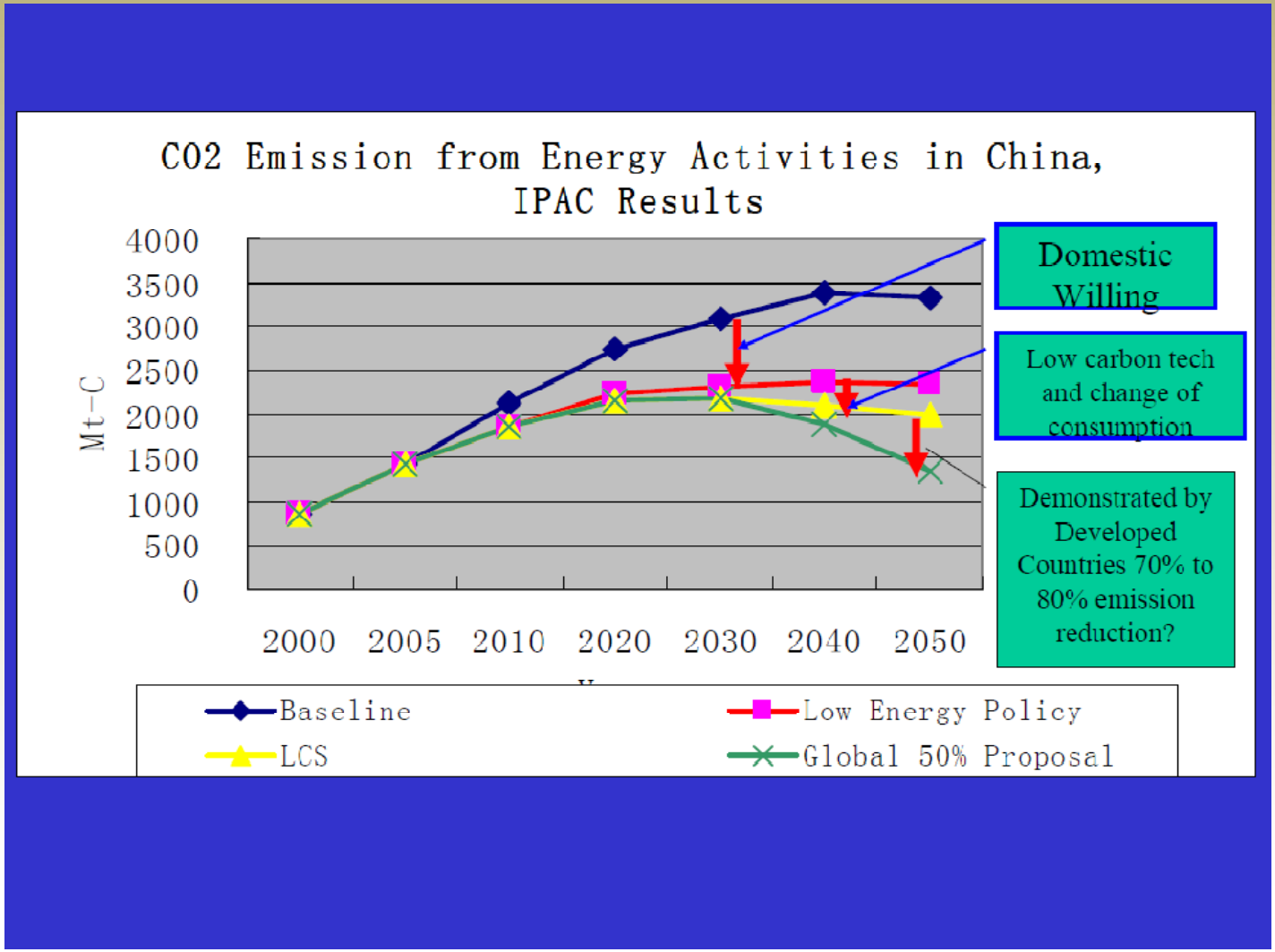
Overview of AIM Project (2/2)
AIM is Team!

Photograph at the 14th AIM Int'l WS at Tsukuba

India China Thailand Korea Malaysia Indonesia Brazil Russia South Africa Taiwan, China USA Japan

AIM Website: http://www-iam.nies.go.jp/aim/

AIM activities with Asian friends(1/3): CO_2 emission projection in China

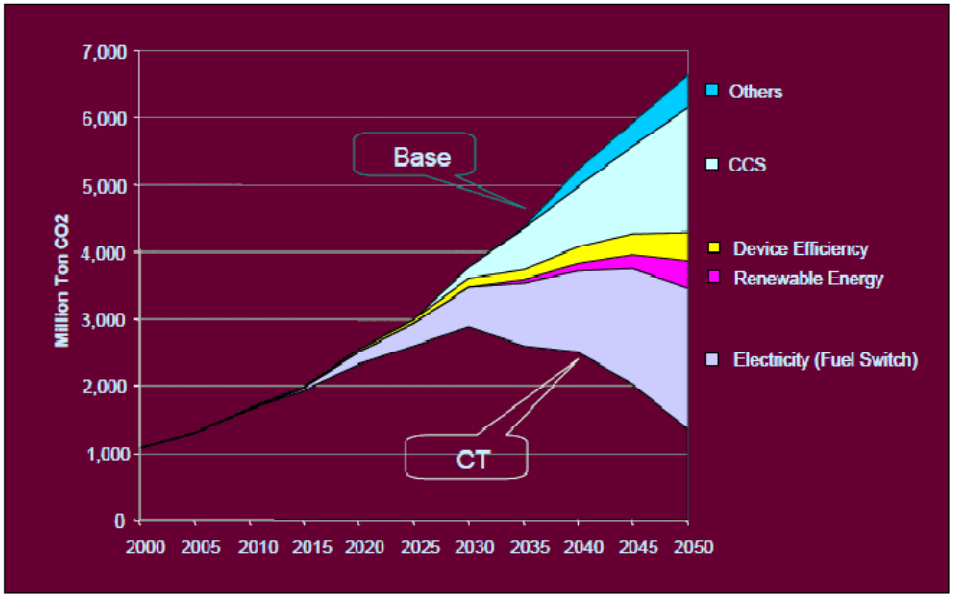


Dr. Jiang Kejun (Energy Research Institute). "Low Carbon Society Scenario up to 2050 for China", The 14th AIM International WS, Tsukuba.

AIM activities with Asian friends (2/3): CO_2 emission projection in India

Vision I: Climate Centric Scenario

1. Top-down/Supply-side actions
2. High Carbon Price as main instrument
3. Climate Focused Technology Push

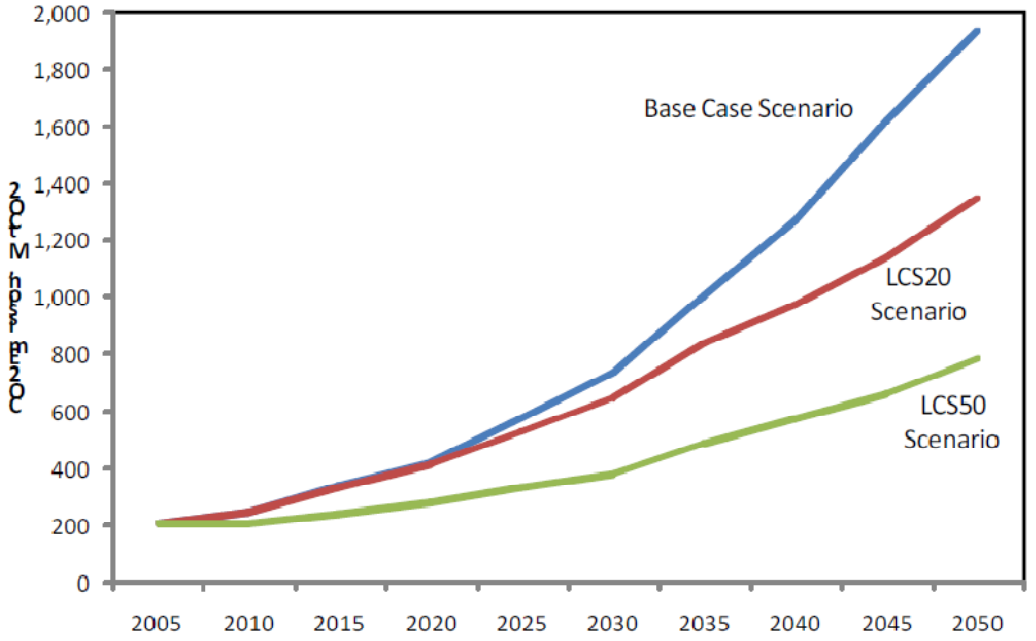


Indian Institute of Management, Ahmedabad, India

Prof. P.R. Shukla (Indian Institute of Management). "Low Carbon Scenarios for India", The 14th AIM International WS, Tsukuba.

AIM activities with Asian friends (3/3): CO_2 emission projection in Thailand

CO_2 emission profiles during 2005-2050 in selected scenarios



- In LCS20, most CO_2 reduction measures would start 2020 onwards.
- In LCS50, the CO_2 reduction need to start much earlier.

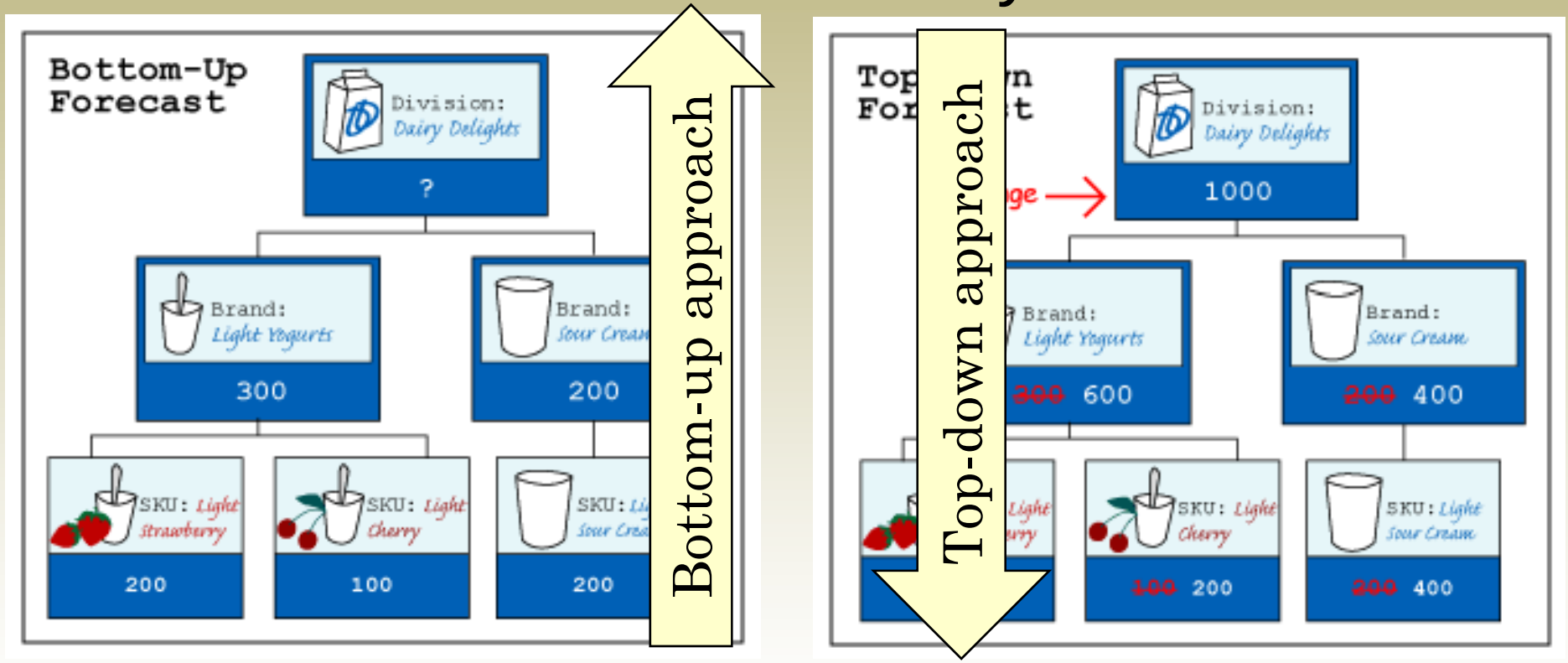
10

Prof. Ram M. Shrestha and Shreekar Pradhan (Asian Institute of Technology). "Low Carbon Scenarios: Case of Thailand", The 14th AIM International WS, Tsukuba.

WAY TO PROJECTION OF GHG EMISSIONS

Two approaches for Projection: Top-down and bottom-up

Macro economy



Micro economy: Energy and Technology

Source: http://www.demandplanning.net/forecast_reconciliation.htm

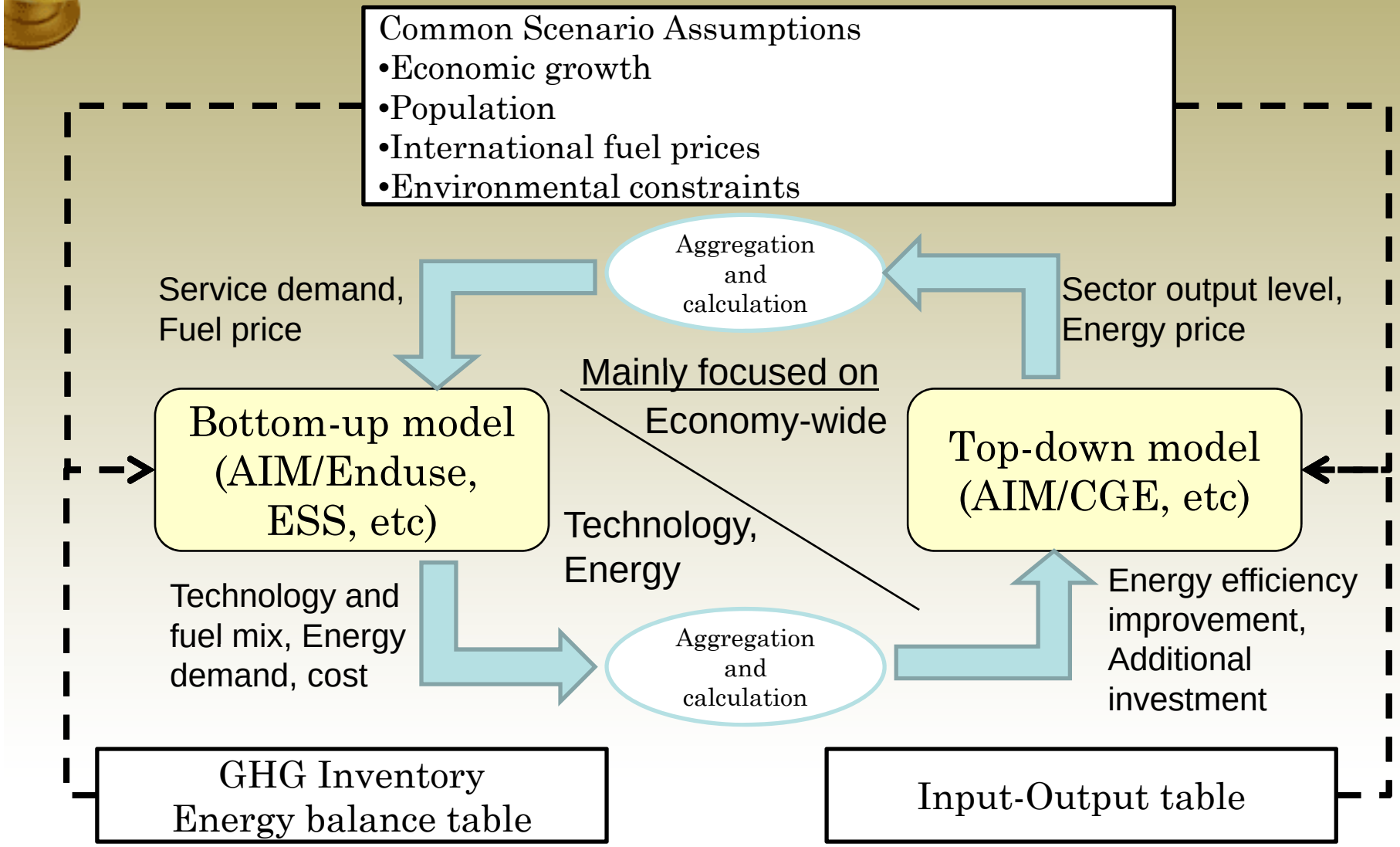
Comprehensive comparison of Top-down and Bottom-up approach

- Top-down approach
  - Computational General Equilibrium model of macro-economic relations inside a country and with other countries
  - Models in this type emphasize economy-wide
- Bottom-up approach
  - technology-rich description of energy system, options and costs (partial equilibria)
  - feature sectoral and technological details

⇒ This is just *"DICHOTOMY"* of the approaches!

There are a lot of Hybrid models which combines the two approach through coupling: part of the CGE economy is described by a bottom up model.

Overview of relationship between two approaches



Source: Based on Xu, Y., Jiang, K. and Masui, T. (2007). "CGE Linkage with AIM/Enduse: Assessing Energy Intensity Reduction Target in China", 13th AIM Int'l WS, Tsukuba.

AIM models for projection of GHG emissions from Top-down approach

AIM/CGE model:

- General Equilibrium model
- Draws the balanced macro economy, based on social conditions such as population, technology and preference, countermeasures

- Programming language: GAMS (The General Algebraic Modeling System)
- Skills required: Macroeconomics (esp. IO analysis), Mathematics (esp. partial differentiation)

AIM models for projection of GHG emissions from Bottom-up approach

AIM/Enduse model:

- Partial equilibrium model on energy
- Assess individual technologies under the detail technology selection framework
- Programming language: GAMS (The General Algebraic Modeling System)
- Skills required: Microeconomics, Mathematics (esp. Linear Optimization theory), and Energy and System Engineering.

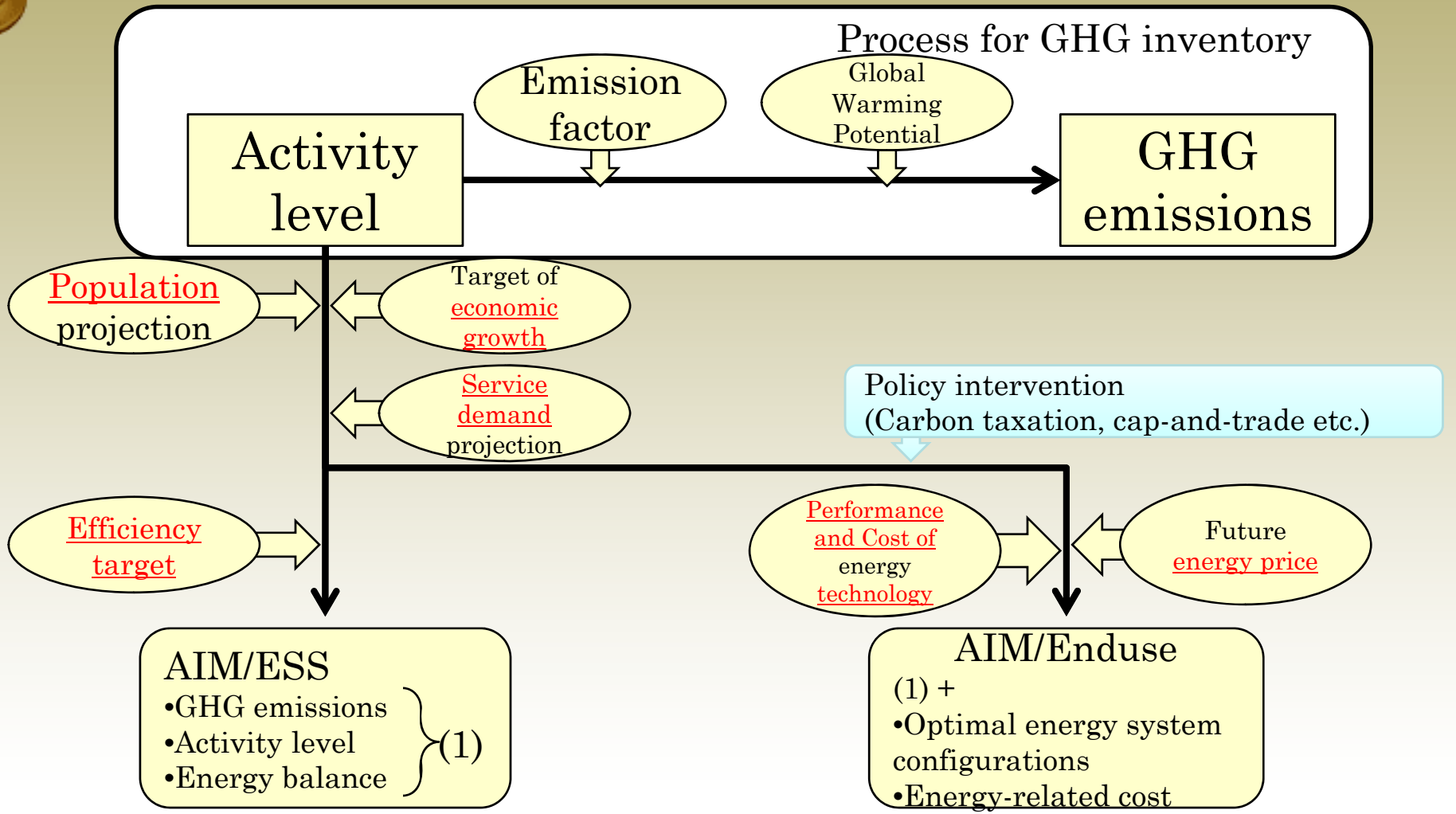
AIM/Energy Snapshot Tool (ESS):

- Snapshot-type tool at a certain point (non-optimization)
- Assess energy balance and GHG emissions among sectors simultaneously
- Programming language: MS Excel (purely spreadsheet-based tool)
- Skills required: Basics of Energy Balance Table

As the information, so the projection

	Top-down	Bottom-up
Activity information from Inventory		✓
Input-Output table of economy	✓	
Socio-economic assumptions		
Population projection	✓	✓
Economic growth	✓	✓
International Fuel Price	✓	✓
Performance and cost of Technology	✓	✓
Environmental constraint	✓	✓

Flow from Inventory to Projection with bottom-up models



Inventory data is one of important basis of bottom-up analysis!

Example (1/2): CO_2 emissions from fossil fuel burning

- CO_2 emissions are derived from energy consumption and emission factors.

CO_2 emissions [tCO_2] =

Energy consumption [MJ]

x Emission factor [tCO_2/MJ]

x Global Warming Potential (1)

Rearrangement of data as tabular form

	Crude oil	Petro. Products	Hydro/ Nuclear	Elec.	Coal/ Gas etc.	Total
Production	0.7	0.0	81.6	0.0	10.5	92.8
Imports	220.3	54.6	0.0	0.0	175.8	450.7
Exports & Stock Change	0.2	-15.2	0.0	0.0	-1.7	-16.7
TPES	221.2	39.4	81.6	0.0	184.6	526.8
Electricity Plants	-0.2	-24.1	-81.6	93.2	-111.0	-130.5
Petro. Refineries	-214.4	212.7	0.0	0.0	0.0	-1.7
Other Transformation	-1.2	-2.1	0.0	-0.1	0.1	-3.3
Own Use / Trans. losses	0.0	-12.3	0.0	-9.3	-4.0	-25.6
Statistical Differences	0.6	6.3	0.0	0.0	0.6	7.5
TFC	0.0	219.9	0.0	83.8	69.5	373.2
Industry	0.0	93.3	0.0	35.9	50.9	180.1
Domestic & Commercial	0.0	37.6	0.0	46.1	18.7	102.4
Transportation	0.0	89.2	0.0	1.9	0.0	91.1

Energy Balance Table!

Projection by AIM/ESS is available

Supplement:
What is Energy Balance Table (EBT)?

- Simple Table Format
- Illustrate general energy flow (production to end-use) of a region
- Flow (in row), Product in column)
  - Input (-), Output (+)

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Industry	0.0	93.3	0.0	35.9	50.9	180.1
Domestic. & Commercial	0.0	37.6	0.0	46.1	18.7	102.4
Transportation	0.0	89.2	0.0	1.9	0.0	91.1

Example (2/2): Non-CO_2 emissions

- Non-CO_2 emissions are derived from activity level, emission factors and GWP.

GHG emissions [tCO_2] =
Activity level [MJ, t, ha, etc]
x Emission factor [[t/MJ, t/ha, etc]
x Global Warming Potential [tCO_2/t]

Rearrangement of data as tabular form

	Crude oil	Petro. Products	Hydro/ Nuclear	Elec.	Coal/ Gas etc.	Total
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Domestic & Commercial	0.0	37.6	0.0	46.1	18.7	102.4
Transportation	0.0	89.2	0.0	1.9	0.0	91.1

Non-CO_2 Balance Table

Projection by AIM/ESS is also available

EXAMPLE OF CO_2 PROJECTION IN JAPAN BY AIM/ESS

Four steps towards emission projection by AIM/ESS

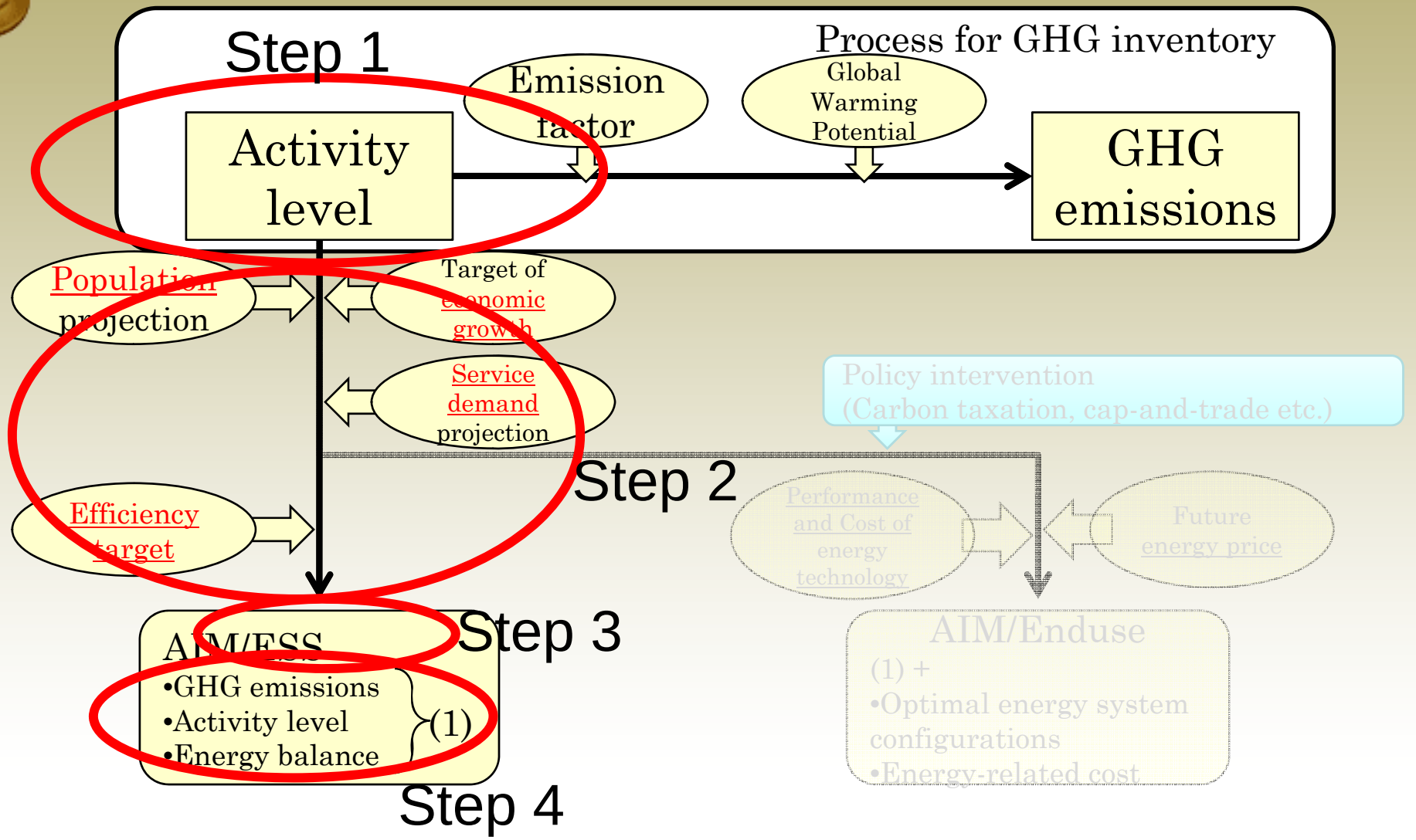
1. Preparations of Energy Balance table in Japan

2. Setting future socio-economic conditions

3. Projection by AIM/ESS

4. Analyzing results

Four steps towards emission projection by AIM/ESS



Step 1:
Preparation of Energy Balance Table

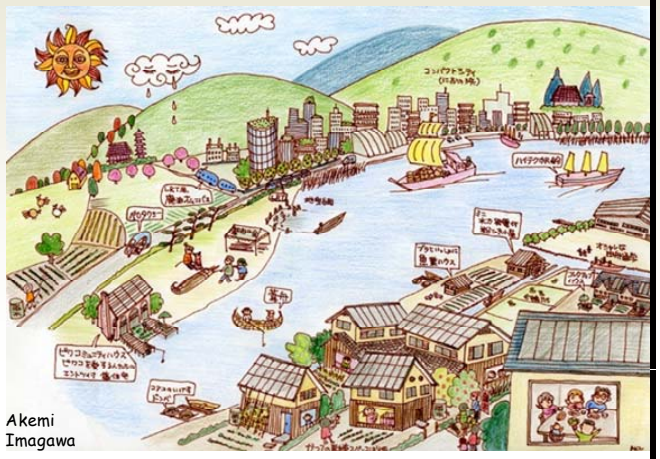
2006FY	100	200	400	450	600	700	800		900
2006FY	石 炭 TJ	原 油 TJ	天然ｶﾞｽ TJ	都市ｶﾞｽ TJ	原子力発電 TJ	電 力 TJ	熱 TJ		合 計 TJ
1000 一次ｴﾈﾙｷﾞｰ	4805862	9115108	3600591	0	2656403	0	0		23770374
1100 国内産出	0	32712	148485	0	2656403	0	0		4299732
1200 輸 入	4805862	9082396	3452106	0	0	0	0		19470643
1500 総供給	4805862	9115108	3600591	0	2656403	0	0		23770374
1600 輸 出	-59	0	0	0	0	0	0		-1009087
1700 供給在庫変動	0	-189967	145407	0	0	0	0		-62158
1900 国内供給	4805802	8925141	3745998	0	2656403	0	0	供給側	22699129
2000 ｴﾈﾙｷﾞｰ転換	-4290961	-9194777	-3695962	1325410	-2656403	3537558	713925		-6916851
2800 純転換部門計	-4353652	-9165887	-3622118	1343461	-2656403	3920737	718088		-6093486
5000 最終ｴﾈﾙｷﾞｰ消費	420204	0	67853	1325410	0	3537369	713925		15977238
6000 産 業	396274	0	67145	220549	0	1188635	689756		7165572
6100 非製造業	174	0	3392	26636	0	10561	0		518435
6500 製造業計	396100	0	63753	193912	0	1178074	689756		6647137
6520 ﾊﾟﾙﾌﾟ紙板紙	0	0	205	1223	0	127183	242205		389386
6550 化 学	8063	0	32238	6556	0	173877	246660		2415096
6570 窯業土石	159450	0	385	1170	0	78735	9376		354157
6580 鉄 鋼	247897	0	24397	63549	0	259649	95019		1760773
6600 機 械	1	0	3872	26698	0	312961	0		377227
6700 重複補正	-23947	0	-642	-1193	0	-24253	-80253		-143737
6900 他業種･中小製造業	1879	0	0	60621	0	94354	129127		1086569
7000 民 生	23930	0	708	1104862	0	2280318	24169		5060629
7100 家 庭	0	0	0	428969	0	1006537	1286		2104917
7500 業務他	23930	0	708	675892	0	1273781	22883		2955712
8000 運 輸	0	0	0	0	0	68415	0		3751037
8100 旅 客	0	0	0	0	0	64846	0		2272524
8500 貨 物	0	0	0	0	0	3568	0		1478512
9000 最終ｴﾈﾙｷﾞｰ用途消費	420204	0	51223	1325410	0	3537369	713925		14088598
9500 非ｴﾈﾙｷﾞｰ利用	0	0	16630	0	0	0	0		1859710

Source: Comprehensive Energy Statistics by METI (2007)

The Energy Balance table is also used for National GHGs Inventory Report of JAPAN

Step 2: Setting future socio-economic conditions (1/2)

- Target Yr: 2050

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
	

http://2050.nies.go.jp

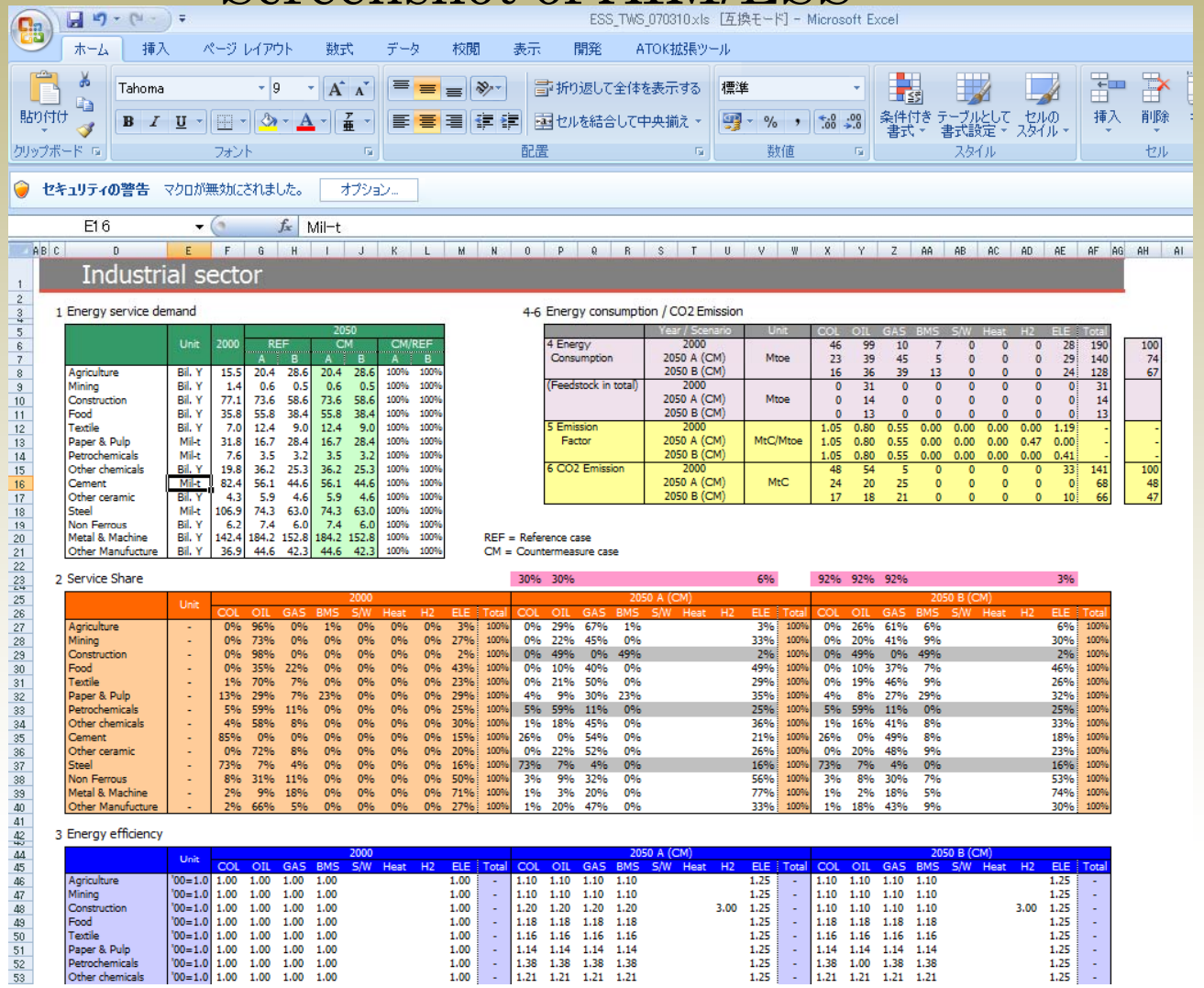
Step 2: Setting future socio-economic conditions (2/2)

year	unit	2000	2050 A	2050 B
Population	Mil.	127	94 (74%)	100 (79%)
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%)
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%)
Travel Passenger volume	bill. p·km	1,297	1045 (81%)	963 (74%)
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%)
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%)

http://2050.nies.go.jp

Step 3: Projection by AIM/ESS (1/3)

Screenshot of AIM/ESS



ESS_TWS_070310.xls [互換モード] - Microsoft Excel

セキュリティの警告 マクロが無効にされました。 オプション...

E16 Mil-t

Industrial sector

1 Energy service demand

	Unit	2000	2050 REF A	2050 REF B	2050 CM A	2050 CM B	CM/REF A	CM/REF B
Agriculture	Bil. Y	15.5	20.4	28.6	20.4	28.6	100%	100%
Mining	Bil. Y	1.4	0.6	0.5	0.6	0.5	100%	100%
Construction	Bil. Y	77.1	73.6	58.6	73.6	58.6	100%	100%
Food	Bil. Y	35.8	55.8	38.4	55.8	38.4	100%	100%
Textile	Bil. Y	7.0	12.4	9.0	12.4	9.0	100%	100%
Paper & Pulp	Mil-t	31.8	16.7	28.4	16.7	28.4	100%	100%
Petrochemicals	Mil-t	7.6	3.5	3.2	3.5	3.2	100%	100%
Other chemicals	Bil. Y	19.8	36.2	25.3	36.2	25.3	100%	100%
Cement	Mil-t	82.4	56.1	44.6	56.1	44.6	100%	100%
Other ceramic	Bil. Y	4.3	5.9	4.6	5.9	4.6	100%	100%
Steel	Mil-t	106.9	74.3	63.0	74.3	63.0	100%	100%
Non Ferrous	Bil. Y	6.2	7.4	6.0	7.4	6.0	100%	100%
Metal & Machine	Bil. Y	142.4	184.2	152.8	184.2	152.8	100%	100%
Other Manufacture	Bil. Y	36.9	44.6	42.3	44.6	42.3	100%	100%

4-6 Energy consumption / CO2 Emission

	Year / Scenario	Unit	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	
4 Energy Consumption	2000	Mtoe	46	99	10	7	0	0	0	28	190	100
	2050 A (CM)		23	39	45	5	0	0	0	29	140	74
	2050 B (CM)		16	36	39	13	0	0	0	24	128	67
(Feedstock in total)	2000	Mtoe	0	31	0	0	0	0	0	0	31	
	2050 A (CM)		0	14	0	0	0	0	0	0	14	
	2050 B (CM)		0	13	0	0	0	0	0	0	13	
5 Emission Factor	2000	MtC/Mtoe	1.05	0.80	0.55	0.00	0.00	0.00	0.00	1.19	-	-
	2050 A (CM)		1.05	0.80	0.55	0.00	0.00	0.00	0.47	0.00	-	-
	2050 B (CM)		1.05	0.80	0.55	0.00	0.00	0.00	0.00	0.41	-	-
6 CO2 Emission	2000	MtC	48	54	5	0	0	0	0	33	141	100
	2050 A (CM)		24	20	25	0	0	0	0	0	68	48
	2050 B (CM)		17	18	21	0	0	0	0	10	66	47

REF = Reference case
CM = Countermeasure case

2 Service Share

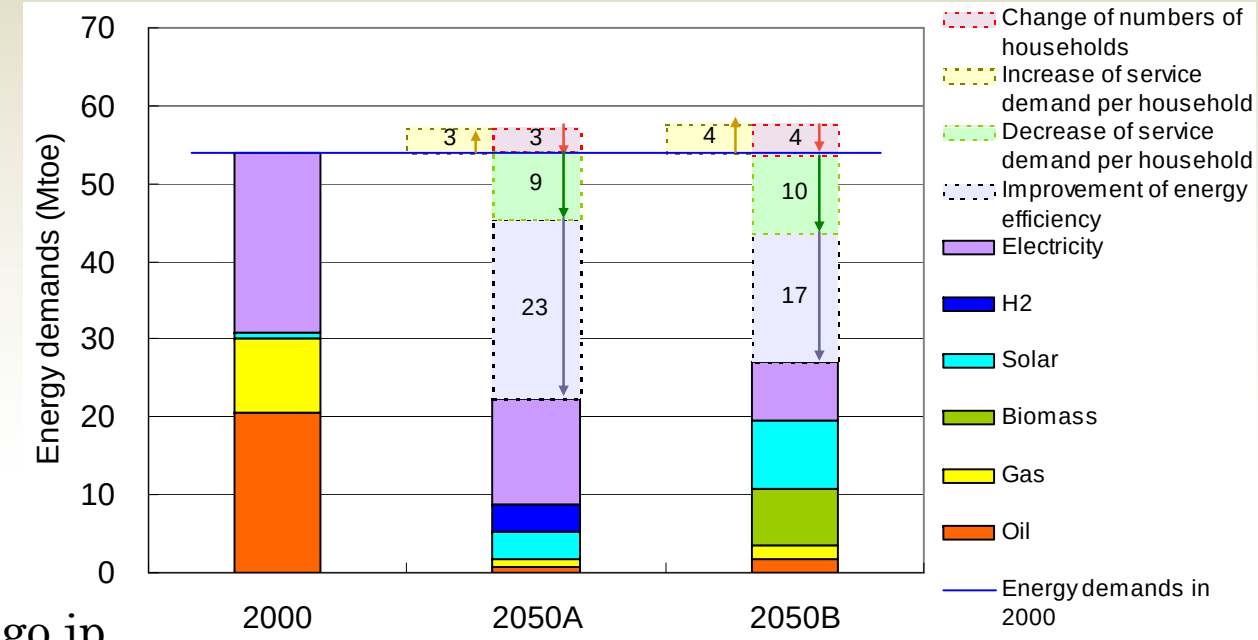
		30%	30%				6%					92%	92%	92%			3%				
	Unit	2000 COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	2050 A (CM) COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	2050 B (CM) COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Agriculture	-	0%	96%	0%	1%	0%	0%	0%	3%	100%	0%	29%	67%	1%				3%	100%	0%	26%	61%	6%				6%	100%
Mining	-	0%	73%	0%	0%	0%	0%	0%	27%	100%	0%	22%	45%	0%				33%	100%	0%	20%	41%	9%				30%	100%
Construction	-	0%	98%	0%	0%	0%	0%	0%	2%	100%	0%	49%	0%	49%				2%	100%	0%	49%	0%	49%				2%	100%
Food	-	0%	35%	22%	0%	0%	0%	0%	43%	100%	0%	10%	40%	0%				49%	100%	0%	10%	37%	7%				46%	100%
Textile	-	1%	70%	7%	0%	0%	0%	0%	23%	100%	0%	21%	50%	0%				29%	100%	0%	19%	46%	9%				26%	100%
Paper & Pulp	-	13%	29%	7%	23%	0%	0%	0%	29%	100%	4%	9%	30%	23%				35%	100%	4%	8%	27%	29%				32%	100%
Petrochemicals	-	5%	59%	11%	0%	0%	0%	0%	25%	100%	5%	59%	11%	0%				25%	100%	5%	59%	11%	0%				25%	100%
Other chemicals	-	4%	58%	8%	0%	0%	0%	0%	30%	100%	1%	18%	45%	0%				36%	100%	1%	16%	41%	8%				33%	100%
Cement	-	85%	0%	0%	0%	0%	0%	0%	15%	100%	26%	0%	54%	0%				21%	100%	26%	0%	49%	8%				18%	100%
Other ceramic	-	0%	72%	8%	0%	0%	0%	0%	20%	100%	0%	22%	52%	0%				26%	100%	0%	20%	48%	9%				23%	100%
Steel	-	73%	7%	4%	0%	0%	0%	0%	16%	100%	73%	7%	4%	0%				16%	100%	73%	7%	4%	0%				16%	100%
Non Ferrous	-	8%	31%	11%	0%	0%	0%	0%	50%	100%	3%	9%	32%	0%				56%	100%	3%	8%	30%	7%				53%	100%
Metal & Machine	-	2%	9%	18%	0%	0%	0%	0%	71%	100%	1%	3%	20%	0%				77%	100%	1%	2%	18%	5%				74%	100%
Other Manufacture	-	2%	66%	5%	0%	0%	0%	0%	27%	100%	1%	20%	47%	0%				33%	100%	1%	18%	43%	9%				30%	100%

3 Energy efficiency

	Unit	2000 COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	2050 A (CM) COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	2050 B (CM) COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Agriculture	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.10	1.10	1.10	1.10				1.25	-	1.10	1.10	1.10	1.10				1.25	-
Mining	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.10	1.10	1.10	1.10				1.25	-	1.10	1.10	1.10	1.10				1.25	-
Construction	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.20	1.20	1.20	1.20			3.00	1.25	-	1.10	1.10	1.10	1.10			3.00	1.25	-
Food	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.18	1.18	1.18	1.18				1.25	-	1.18	1.18	1.18	1.18				1.25	-
Textile	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.16	1.16	1.16	1.16				1.25	-	1.16	1.16	1.16	1.16				1.25	-
Paper & Pulp	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.14	1.14	1.14	1.14				1.25	-	1.14	1.14	1.14	1.14				1.25	-
Petrochemicals	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.38	1.38	1.38	1.38				1.25	-	1.38	1.00	1.38	1.38				1.25	-
Other chemicals	'00=1.0	1.00	1.00	1.00	1.00				1.00	-	1.21	1.21	1.21	1.21				1.25	-	1.21	1.21	1.21	1.21				1.25	-

Step 3: Projection by AIM/ESS (2/3)
Changes in energy demands in the residential sector

		2000									2050 A (CM)									2050 B (CM)								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Warm	Mtoe	0.0	10.9	2.8	0.0	0.0	0.0	0.0	1.2	14.9	0.0	0.5	0.5	0.0	0.0	0.9	0.0	0.9	2.8	0.0	0.5	0.5	4.5	0.0	0.0	0.0	0.4	5.9
Hot Water	Mtoe	0.0	8.4	5.0	0.0	0.8	0.0	0.0	1.0	15.2	0.0	0.3	0.3	0.0	0.6	0.6	0.0	0.7	2.4	0.0	1.0	1.0	2.0	2.9	0.0	0.0	0.5	7.3
Cooking (S)	Mtoe	0.0	1.2	1.6	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.7	0.8	0.0	0.3	0.4	0.7	0.0	0.0	0.0	0.4	1.8
Cooking (E)	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6
Lighting	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3
Refrigerator	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.2
TV	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Appliance	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	6.5
	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Generation	Mtoe									0.0					7.6			-2.9	4.7					15.5			-5.9	9.6
Cogeneration	Mtoe									0.0						-1.5	3.6	-1.6	0.5						0.0	0.0	0.0	0.0
	Mtoe									0.0									0.0									0.0
Total	Mtoe	0	21	9	0	1	0	0	23	54	0	1	1	0	8	0	4	14	27	0	2	2	7	18	0	0	7	37



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Step 3: Projection by AIM/ESS (3/3)
Future energy balance table and CO_2 emissions

Future energy balance table and CO_2 emissions

		COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total
Energy Balances												
	Power Gnr.	15	0	41	0	92	8	1			-66	90
	CCS										3	3
	Heat											0
	Coal/Oil/Gas		2									2
	Hydrogen			12				13		-14		11
	Industrial	23	39	45	5			0	0	0	29	140
	Residential	0	1	1	0			8	0	4	14	27
	Commercial	0	1	1	0			3	0	5	18	28
	Trans. Prv.	0	4	0	2			0	0	3	2	11
	Trans. Frg.	0	3	0	9			0	0	3	1	17
	Enduse	23	48	47	16			11	0	14	64	223
	Total	38	50	100	16	92	8	25	0	0	-0	330
	Feedstock in total		14									
Emission Factor (MtC/Mtoe)		1.05	0.80	0.55	0.00	0.00	0.00	0.00	(0.00)	(0.47)	(0.00)	
CO2 Gnr. (MtC)		40	29	55	0	0	0	0	-	-	-	124
CO2 CCS (MtC)		-16		-23					-	-	-	-39
												0
												0
CO2 Ems. (MtC)		24	28.6	33	0	0	0	0	-	-	-	85

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Step 4: Analyzing results (1/2)
Factor analysis of CO_2 reduction by Kaya-identity

$$C = D \times \frac{E}{D} \times \frac{C'}{E} \times \frac{C}{C'} \quad \text{(Extended Kaya-identity)}$$

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

D: Driving forces (service demand)

E: Energy Consumption

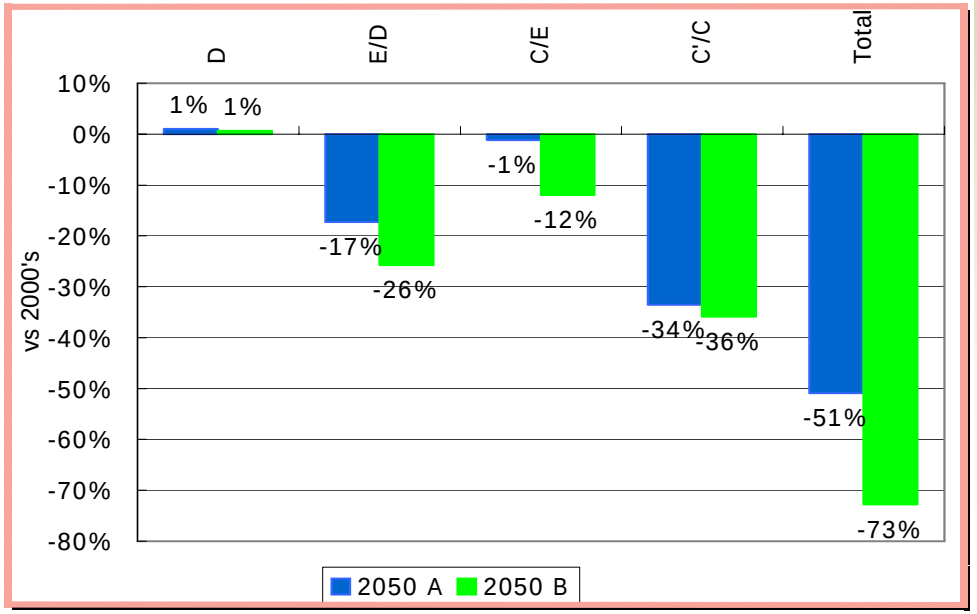
C': CO_2 emission without measures in transformation ector

C: CO_2 emission with measures in transformation sector

E/D: Energy Intensity

C'/E: CO_2 intensity in end-use sector (without measures in transformation sector)

C/C': Change of CO_2 intensity by measures in transformation sector



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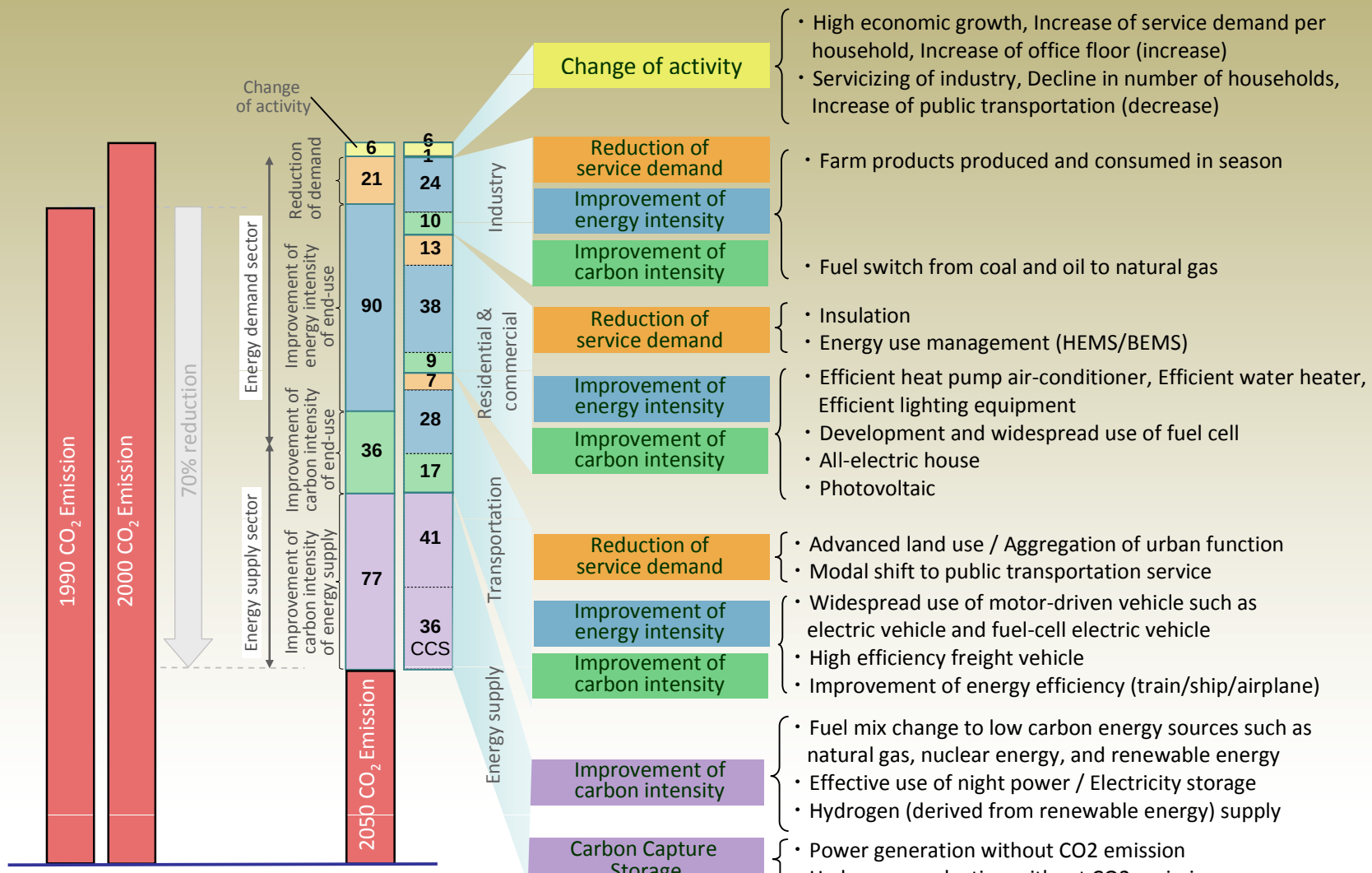
Step 4: Analyzing results (2/2)
Factor analysis of CO_2 reduction: Summary



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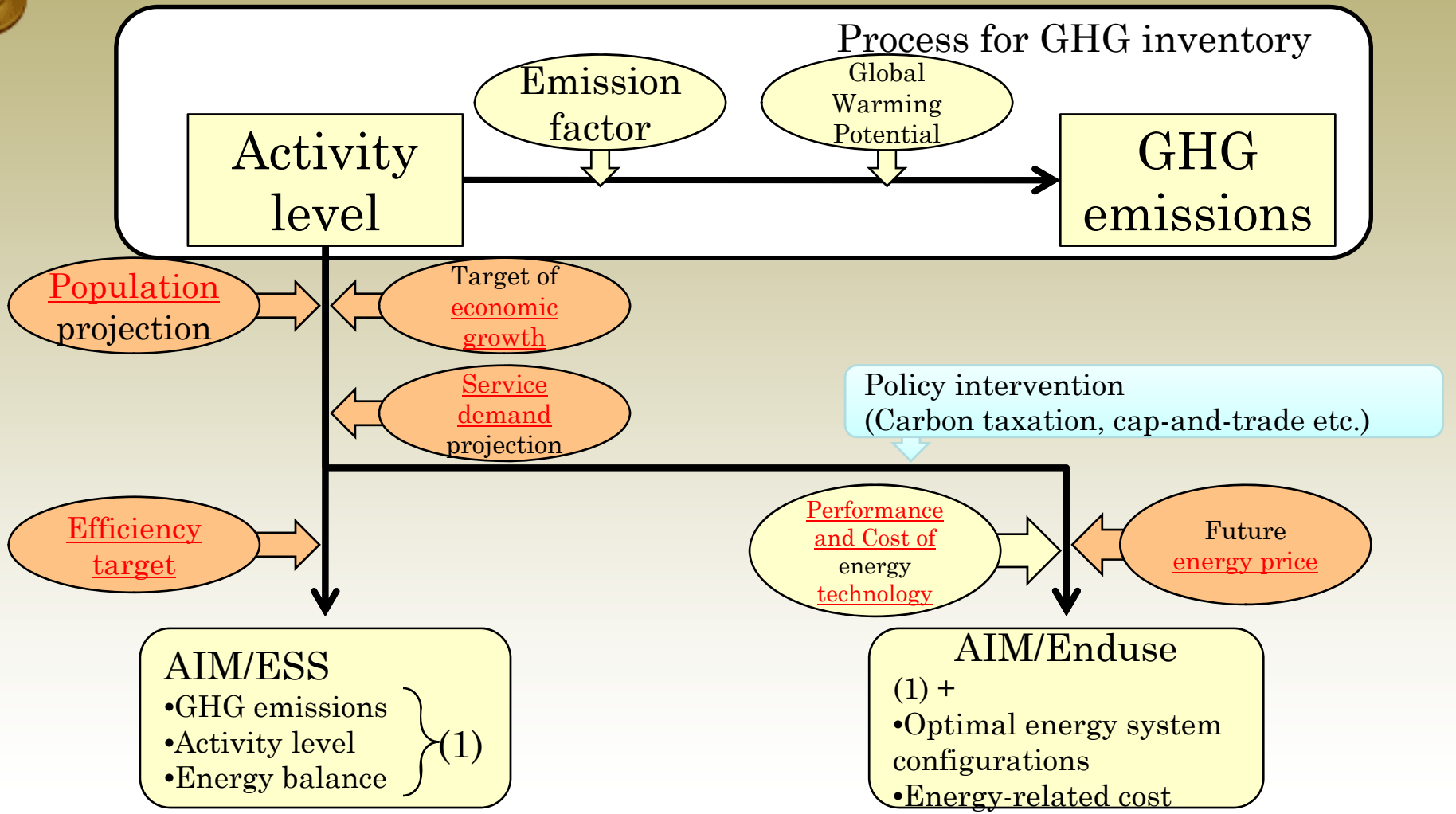
FOR MORE DETAILED AND ROBUST PROJECTION

Model evaluation of Socio-economic conditions



Nine national/regional scale models for projecting energy services, energy consumption, their management etc. (*Element models*)

1. **AIM/Enduse[country]:** National level bottom-up engineering type model for energy supply/consumption
2. **Macro-economy model (EME):** Supply-side type mid-term econometric model
3. **Population/Household dynamics model (PHM):** to describe each country's demographic dynamics
4. **House and building dynamics model (BDM):** to describe transition and renovation dynamics towards modern and highly insulated buildings.
5. **Traffic demand model (TDM):** to describe passenger and freight transports coupled with economic activity and urban structure
6. **Material stocks and flow model (MSFM):** to describe material metabolism towards sustainable material societies
7. **Energy supply model (ESM):** to describe scenarios of renewables energy supply, power infrastructure development
8. **Household production and lifestyle model (HPLM):** to describe the transition of household consumption, lifestyle etc.
9. **AIM/Enduse[air]:** an atmospheric environment model to estimate co-benefits caused by environmental carbon policies.

Population and Household Model

- A cohort component model for population, a household headship rate model for household types, with spatial resolution of provinces, land-use types and climate zones and five family types
- Analyzing effects of depopulation and changes in family composition on the future population projection.

Input

Nation's and Province-wise:

- Base year's population
- Expected life table
- Expected fertility rate
- Expected migration rate

- Information on land-use types and climatic zones by province-wise resolution

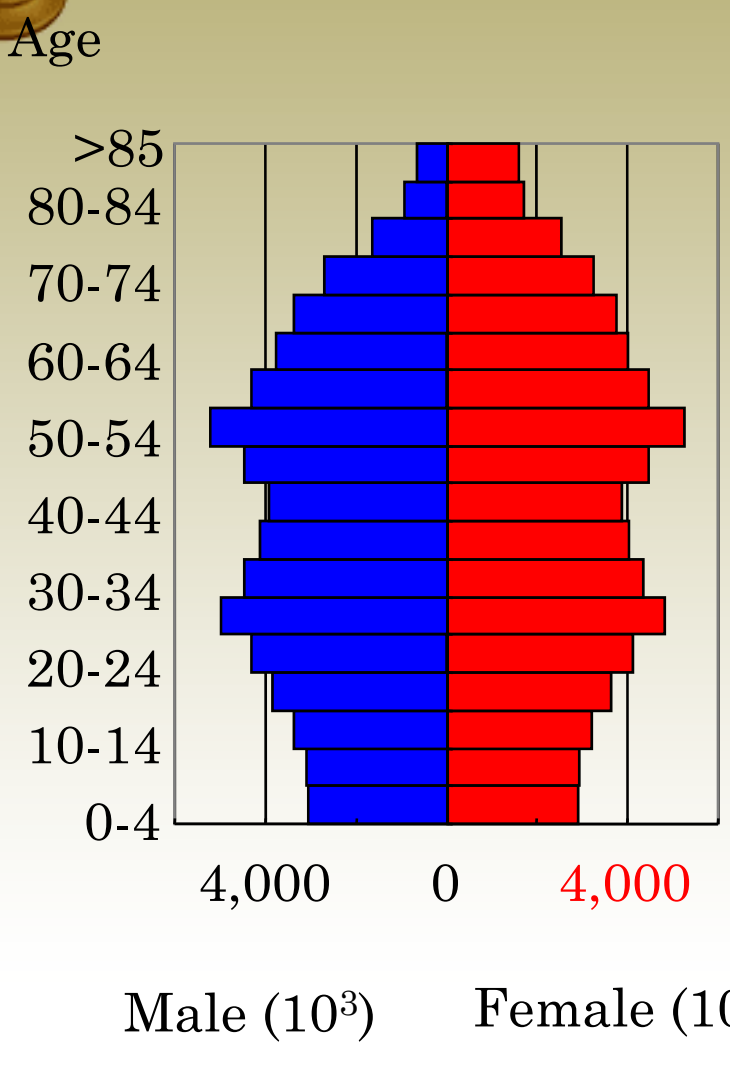
Output

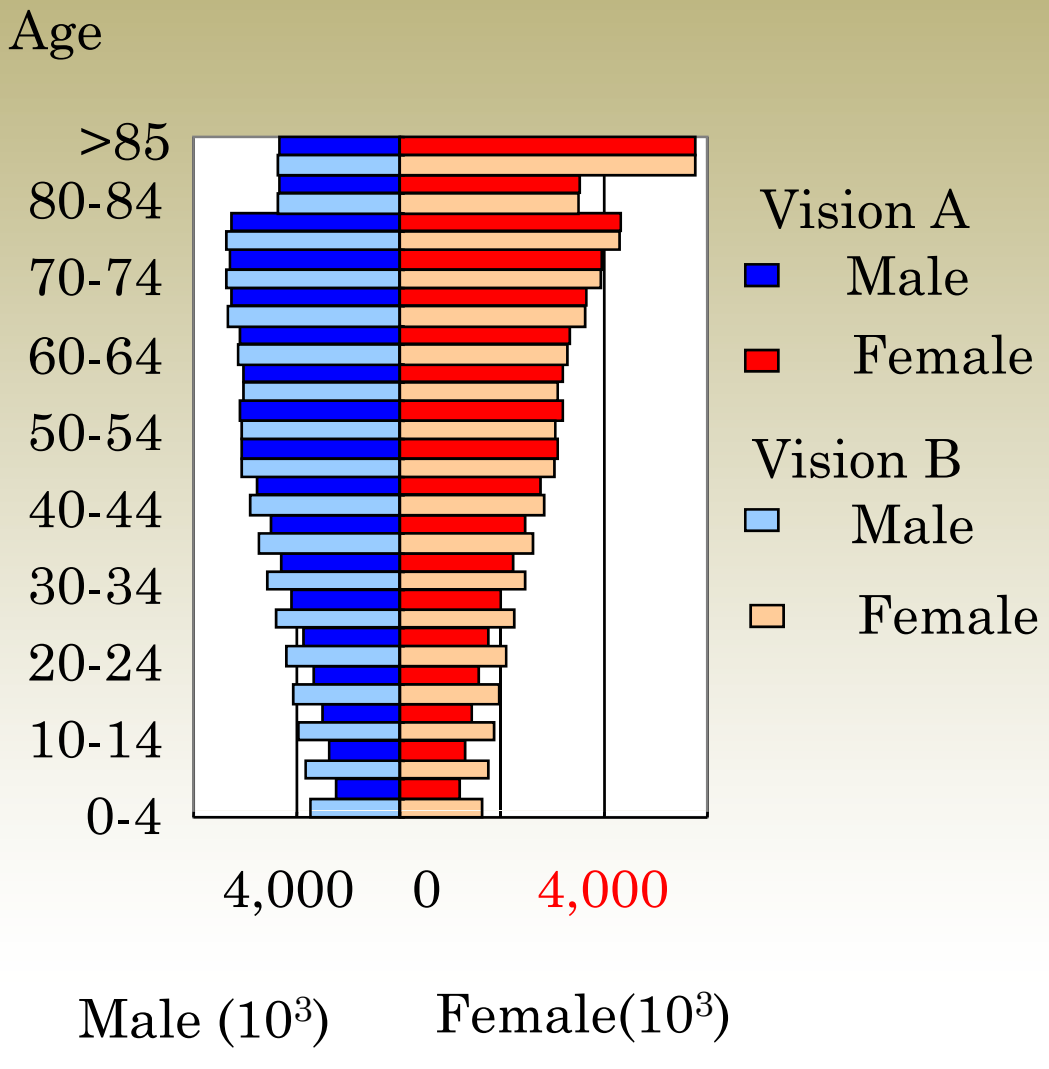
Nation's and Province-wise:

- Future population by age and sex
- Number of households by family type

- Population and Households by climatic zone and land-use classification

Demographic composition in Japan





Building Dynamics Model

- A cohort model with a spatial resolution of climate zones, four heat insulation levels, four residential building types, and six commercial building types.

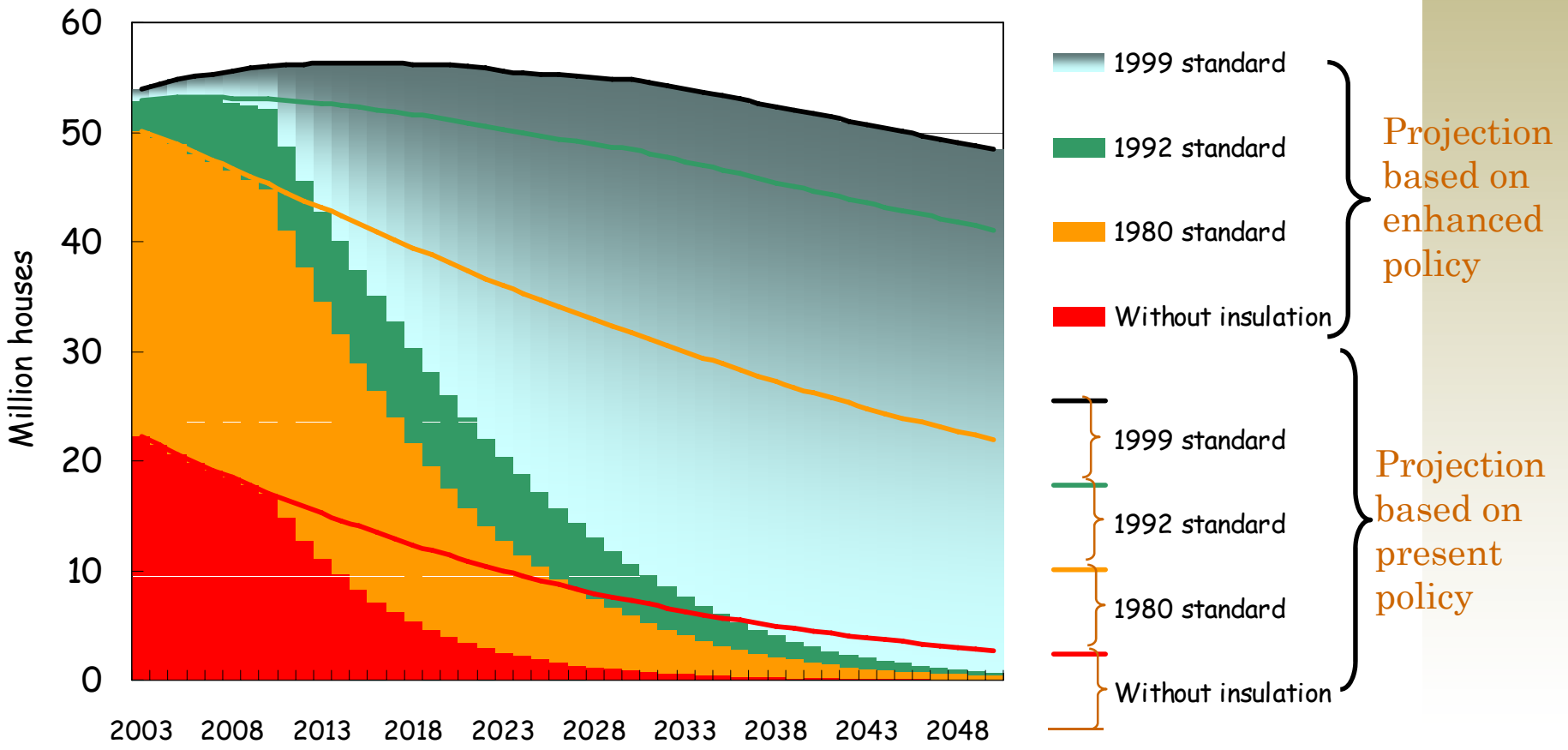
Input

- Dwelling stock in the base year
- Residual ratio
- Number of households
- Regional/Building type distribution of new dwellings
- Retrofit of existing dwelling stock
- Average floor space of new dwellings

Output

- Number and the floor space of future dwelling stock by
  - Region
  - Building type
  - Construction period

Projection of residential building stock by insulation level



Passenger Transportation Demand Model

- Simulates transportation demand associated with changes in population distribution, social environment, personal activity patterns, modal share, and average trip distance.
- Based on the transportation model developed by Japan's Ministry of Land Infrastructure and Transport (MLIT).

Input

- License holding ratio
- Trip generation coefficient
- Modal share
- Average trip distance
- Net total conversion ratio

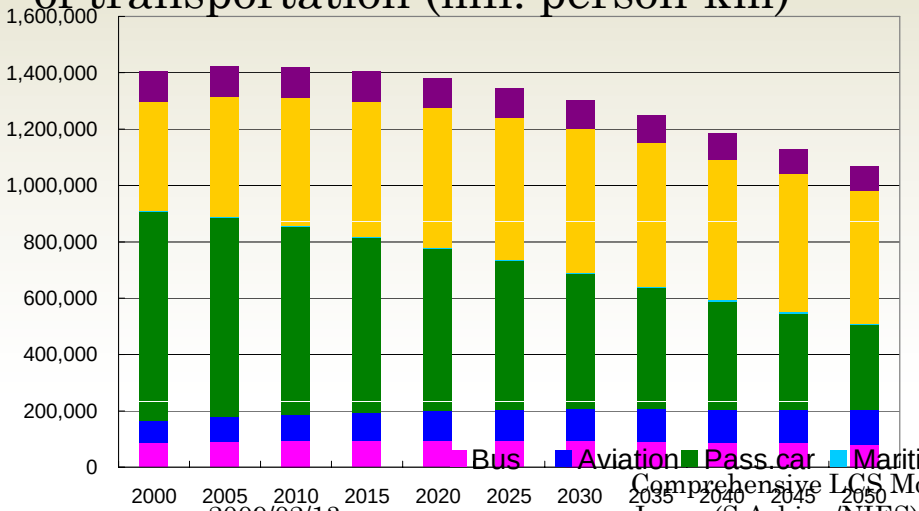
Output

- Net transportation demand
- Total passenger transportation demand

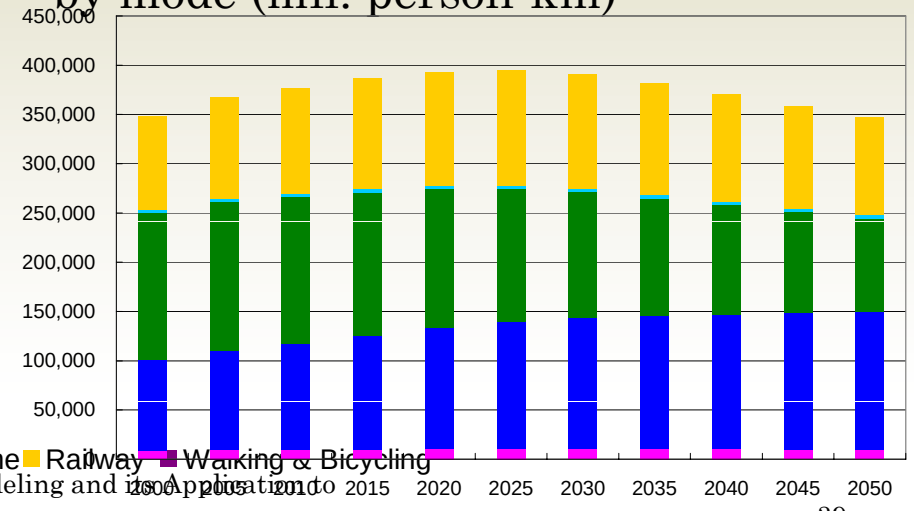
Passenger Transportation Demand Model: Application to Japan

Indices	Example of element
Personal attribute	Several groups depending on age, sex, employment, etc.
Day	Weekday, holiday
Land area	Urban, mountainous, agricultural, etc.
Mode	Car, bus, railway, aviation, maritime, walking & bicycling, etc.
Objective	Work, school, return, business, private & shopping, etc.
Simulation time	Every 5 years between 2000 and 2050

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



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



THANK YOU FOR YOUR ATTENTION!

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FURTHER INFORMATION

AIM Website:

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

LCS Project Website:

http://2050.nies.go.jp/