Greenhouse Gas Emissions Technical Mitigation Potentials and Costs in 2020 - The Revised Edition -

Tatsuya Hanaoka
National Institute for Environmental Studies

2nd International Bottom-up Based Analysis on Mitigation Potential
Novotel Paris Tour Eiffel, Paris, France
21th October, 2008

Objective

1) **Estimation of marginal abatement costs and evaluate GHG mitigation potentials** in world regions.
   - Region-wise mitigation potentials and costs
   - Sector-wise mitigation potentials and costs

2) Analysis of the impact of policy instruments and consequent effects on GHG emission reductions.
   - possibility of achievement of required reduction under stabilization constraints

Geographical coverage

Focusing on major GHG emission regions, especially Again regions in detail

Region	Code	Annex[1)]
1) Japan	JPN	A I
2) China	CHN	NA I
3) India	IND	NA I
4) Indonesia	IDN	NA I
5) Korea	KOR	NA I
6) Thailand	THA	NA I
7) Other South-east Asia	XSE	NA I
8) Other South Asia	XSA	NA I
9) Middle East	XME	NA I
10) Australia	AUS	A I
11) New Zealand	NZL	A I
12) Canada	CAN	A I
13) USA	USA	A I

Region	Code	Annex[1)]
12) Canada	CAN	A I
13) USA	USA	A I
14) EU-15 in Western Europe	XE15	A I
15) EU-10 in Eastern Europe	XE10	A I
16) Russia	RUS	A I
17) Argentine	ARG	NA I
18) Brazil	BRZ	NA I
19) Mexico	MEX	NA I
20) Other Latin America	XLM	NA I
21) South Africa	SAF	NA I
22) Other Africa	XAF	NA I
23) Rest of the World	XRW	NA I

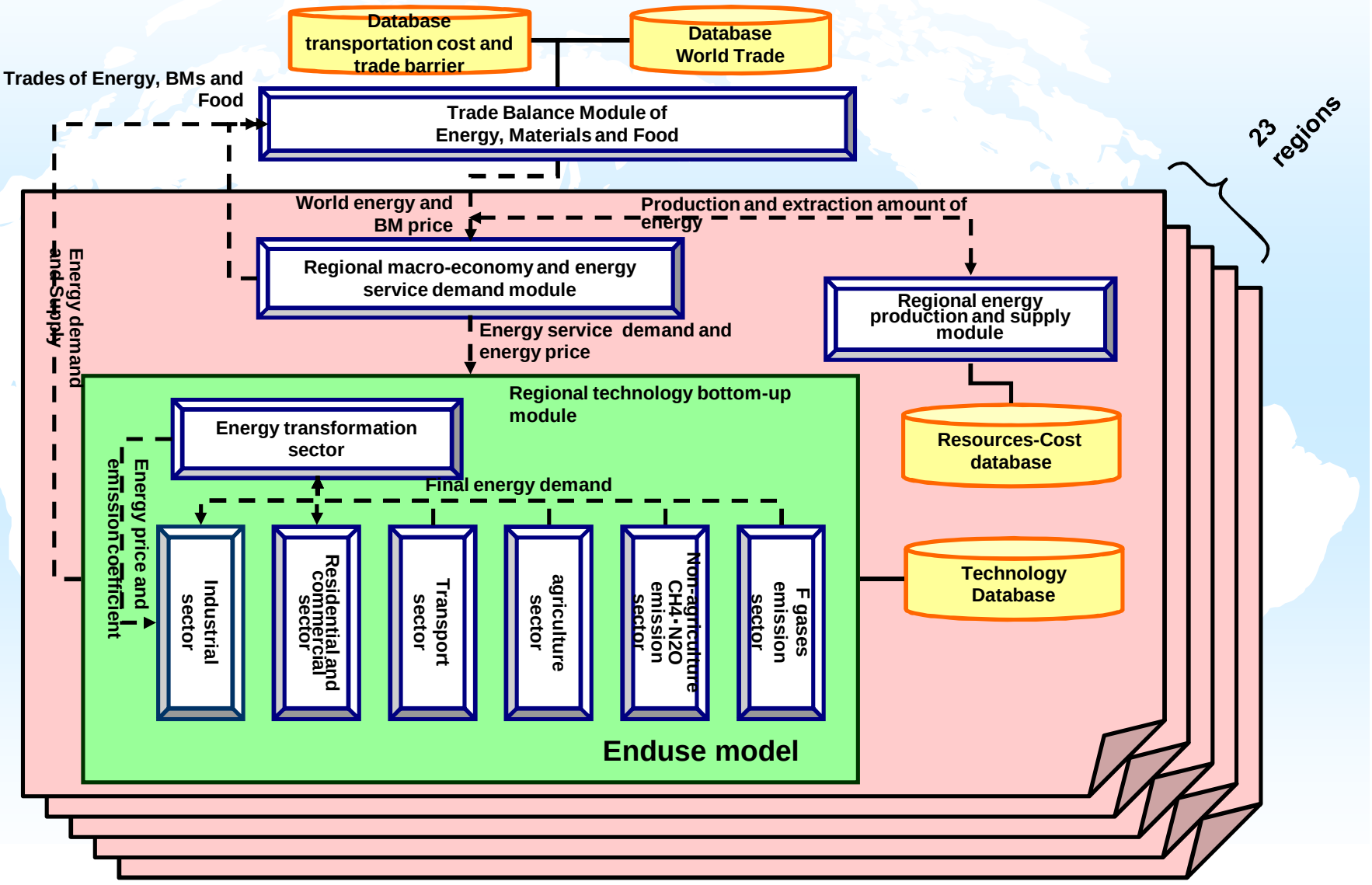
Note1) A I = Annex I nations, NA I = non-Annex I nations

Target gas and sectors

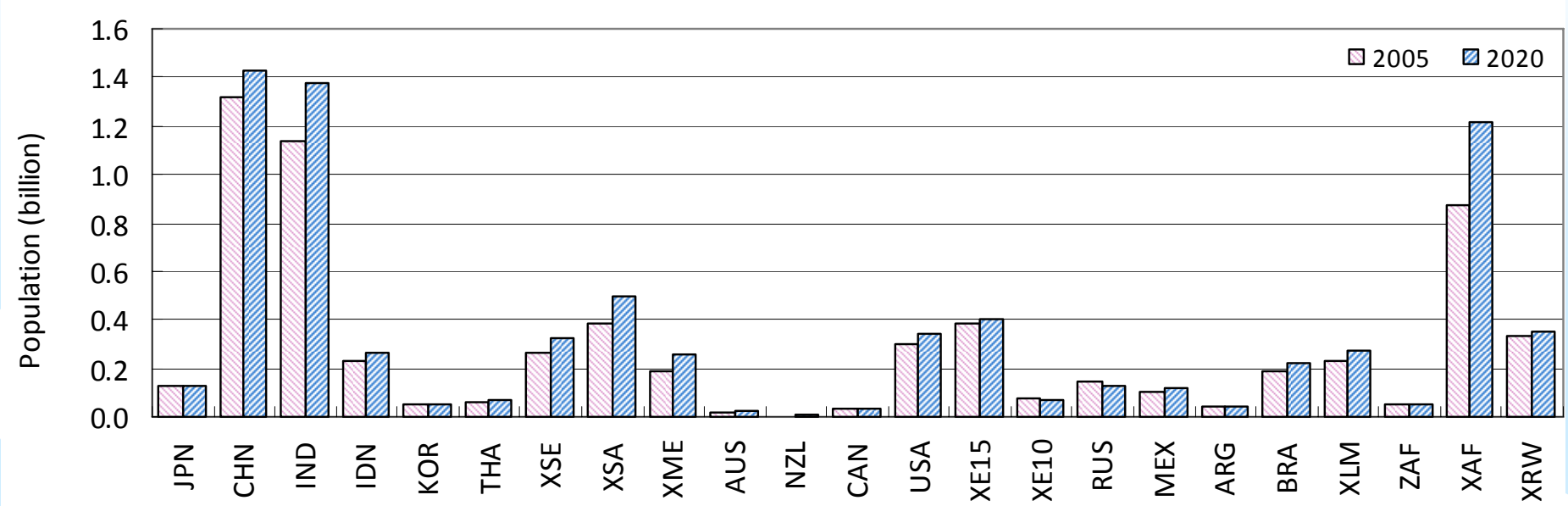
GHG	Sector	Services
CO_2 CH_4 N_2O	Power generation	Coal power plant, Oil power plant, Gas power plant, Renewable (Wind, Biomass, PV)
	Industry	Iron and steel, Cement
		Other industries（Boiler, motor etc）
	Transportation	Passenger vehicle, Truck, Bus, Ship, Aircraft, Passenger train, Freight train (except for pipeline transport and international transport)
	Residential & Commercial	Cooling, Heating, Hot-water, Cooking, Lighting, Refrigerator, TV (only residential)
CH_4 N_2O	Agriculture	Livestock rumination, Manure management, Paddy field, Clopland
	MSW	Municipal solid waste
CH_4	Fugitive	Fugitive emission from fuel
HFCs, PFCs,SF_6	Fgas emissions	By-product of HCFC-22, Refrigerant, Aerosol, Foams, Solvent, Etching, Aluminum production, Insulation gas, others.

- Nuclear power plant is included in the base line but it is not considered as a mitigation option in this study.

Overview of Enduse[Global]



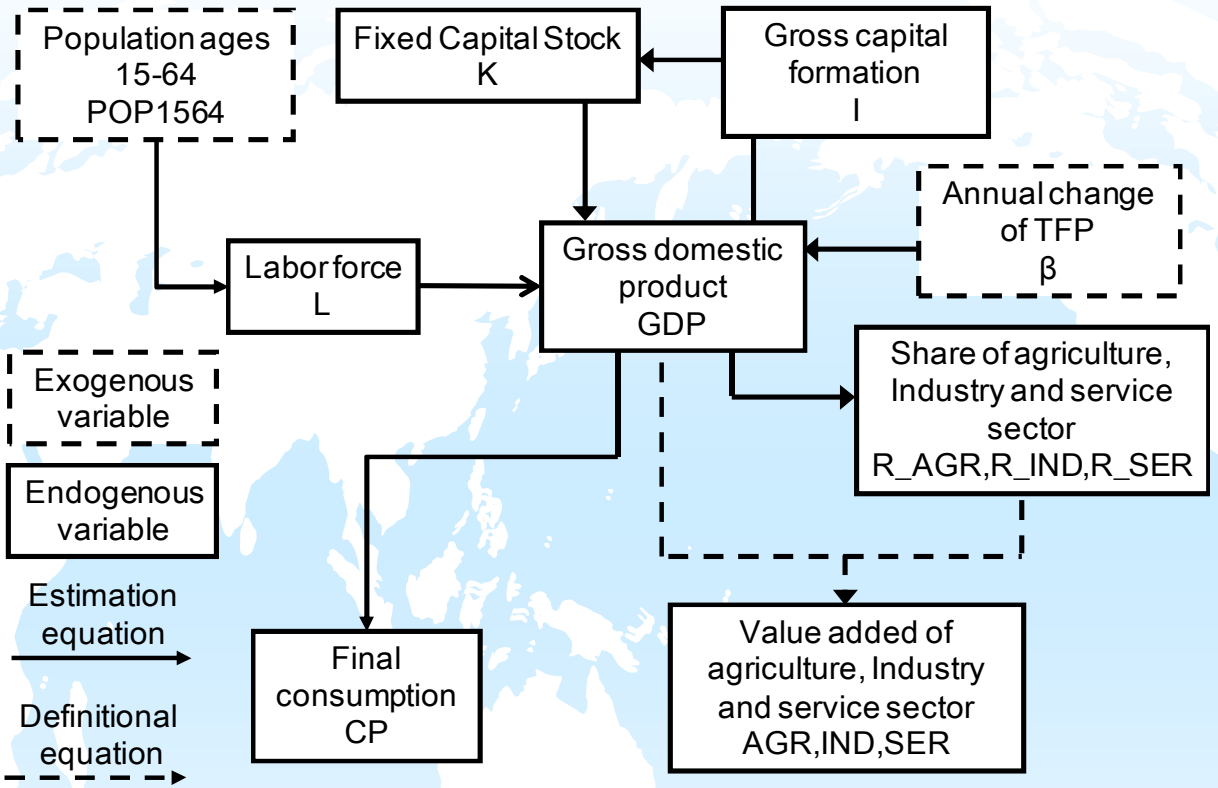
Population in 2005 and 2020



- **The population growth is set based the prospects at medium variant by UN World Population Prospects 2007 .**
- **Annual growth rate from 2005 to 2020 in major countries**

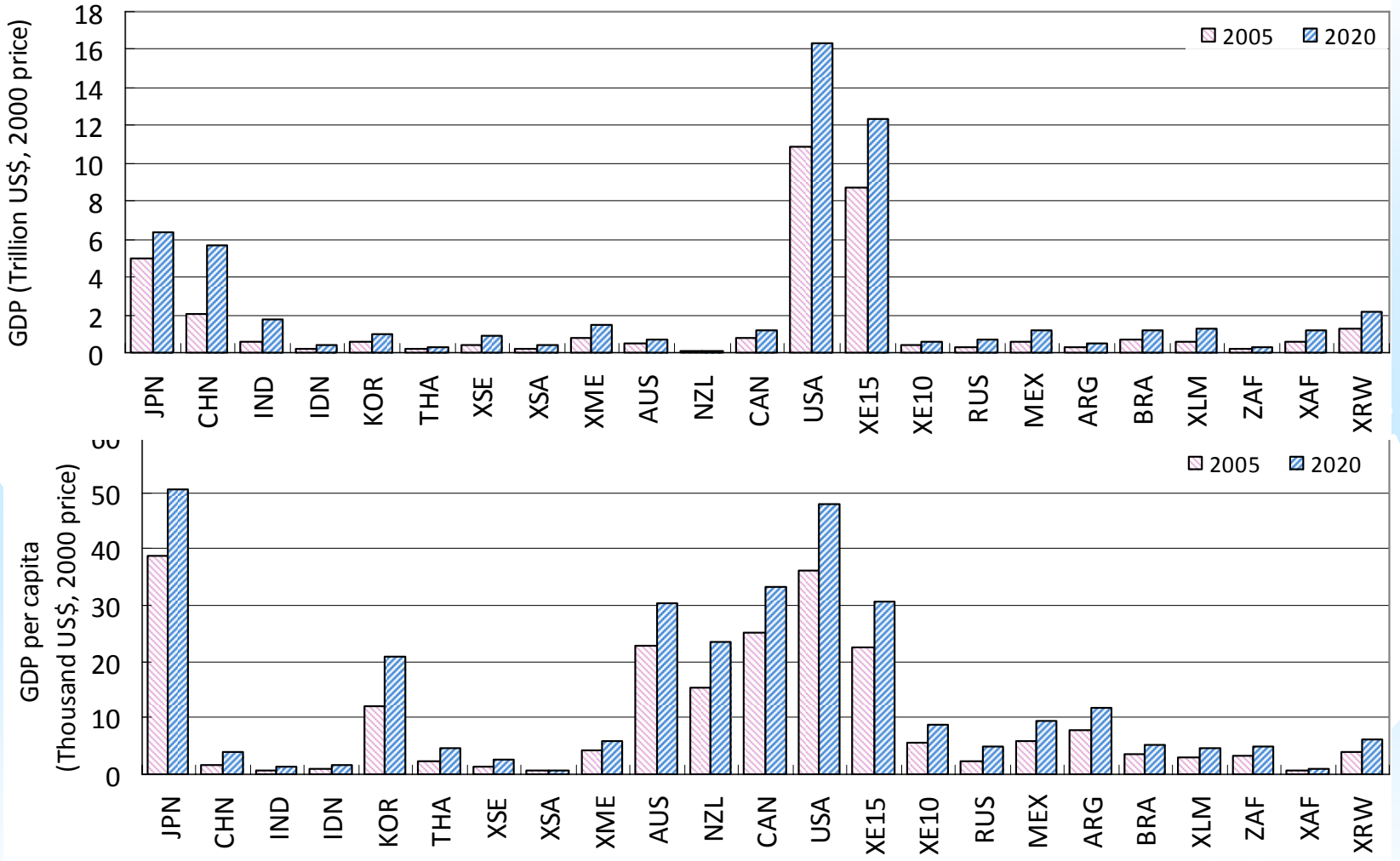
	JPN	CHN	IND	IDN	KOR	USA	XE15	XE10	RUS	BRA	World
'20/'05	-0.2%	0.5%	1.3%	1.0%	0.2%	0.9%	0.2%	-0.2%	-0.6%	1.1%	1.1%

Socio-economic Macro Frame model



- **The Socio-economic Macro Frame model estimates GDP by using data of labor force, fixed capital stock, and annual changes of total factor productivity (TFP). GDP is estimated based on the production function of Cobb-Douglas type.**
- **Output of this model are GDP, value added of primary, secondary and tertiary industries, final consumption, gross capital formation, etc.**
- **These economic values are in real terms of the year 2000 levels.**

GPD & GDP per capita in 2005 and 2020

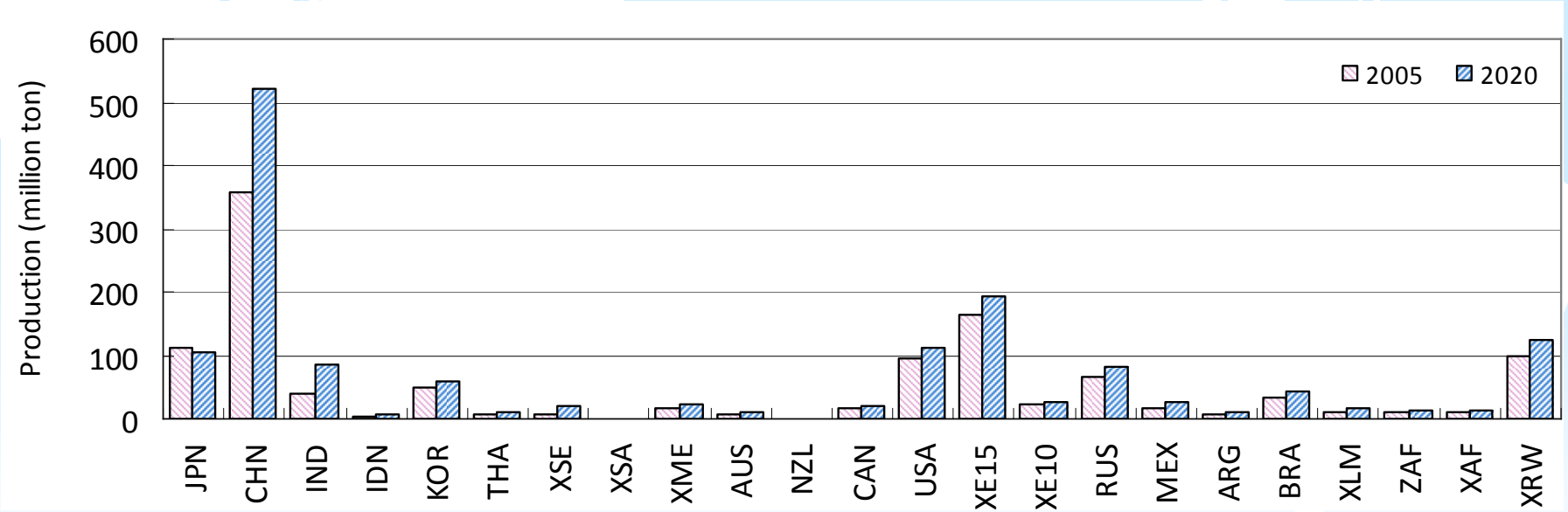


- **Annual growth rate of GDP per capita from 2005 to 2020**

	JPN	CHN	IND	IDN	KOR	USA	XE15	XE10	RUS	BRA	World
'20/'05	1.8%	6.5%	5.9%	3.5%	3.7%	1.9%	2.1%	3.2%	5.2%	2.8%	2.1%

Steel Production and Trade model

- **This model is the partial equilibrium model which considers iron and steel price and the balances of interior and international demand and supply.**
- **In developed countries, annual growth rates range from -0.4 to 1.1%/year, whereas annual growth rates are very high in developing countries; 2.6%/year, 5.6 %/year in China, India respectively.**

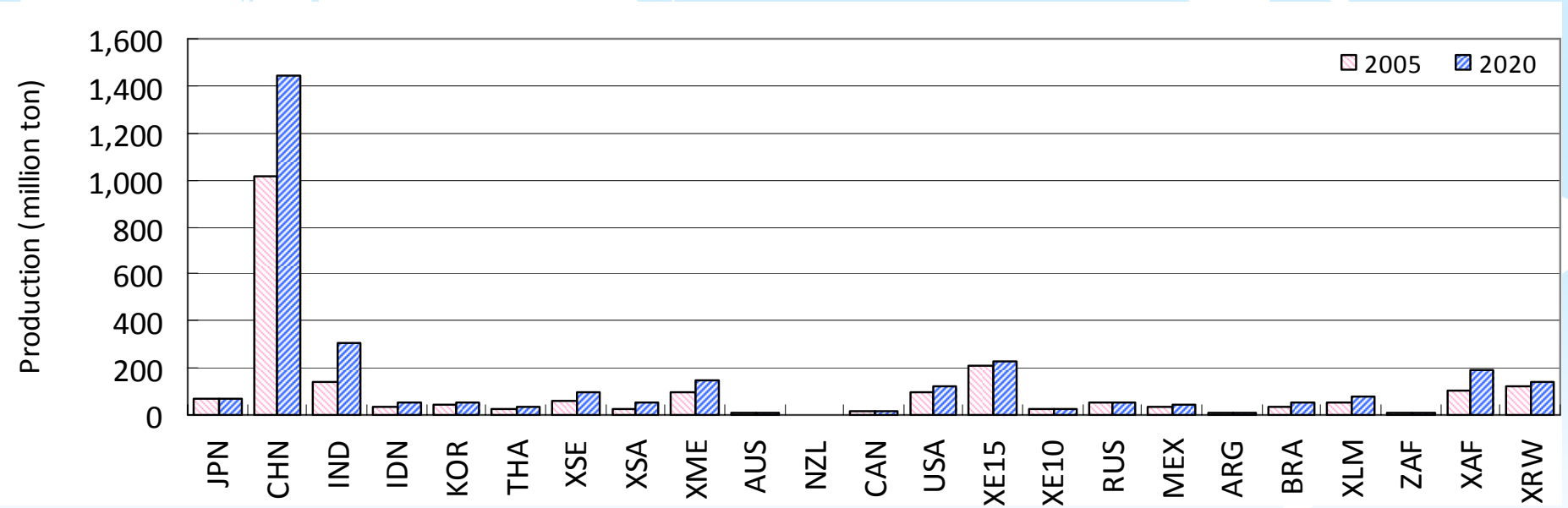


- **Annual growth rate of crude steel production from 2005 to 2020**

	JPN	CHN	IND	IDN	KOR	USA	XE15	XE10	RUS	BRA	World
'20/'05	-0.4%	2.6%	5.6%	2.8%	1.5%	1.1%	1.0%	1.4%	1.5%	2.0%	2.0%

Cement Production model

- **The share of global trade in the global production is small (4~8%), thus cement production are estimated by domestic production and consumption, without considering global trade.**
- **In OECD countries, annual growth rates range from -0.1 to 1.6%/year, whereas annual growth rate are very high in non-OECD countries; 2.4%/year, 5.3%/year, in China, India respectively.**

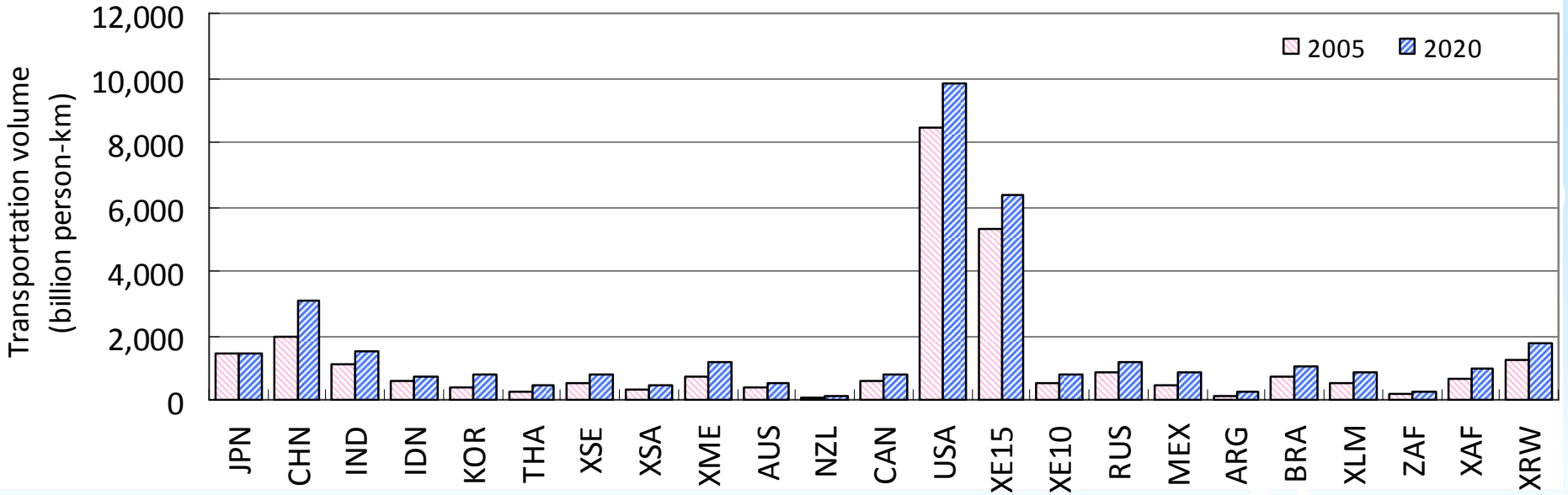


- **Annual growth rate of cement production from 2005 to 2020**

	JPN	CHN	IND	IDN	KOR	USA	XE15	XE10	RUS	BRA	World
'20/'05	-0.1%	2.4%	5.3%	3.3%	0.7%	1.3%	0.4%	0.2%	0.4%	2.6%	0.8%

Passenger Transportation Demand model

- **In the passenger transportation demand model, net passenger transportation volume is estimated by multiplying population by net transportation volume per capita, and transport share is estimated by per capita GDP, thus transportation volume in different transportation mode are determined by multiplying net transportation volume by transport share.**

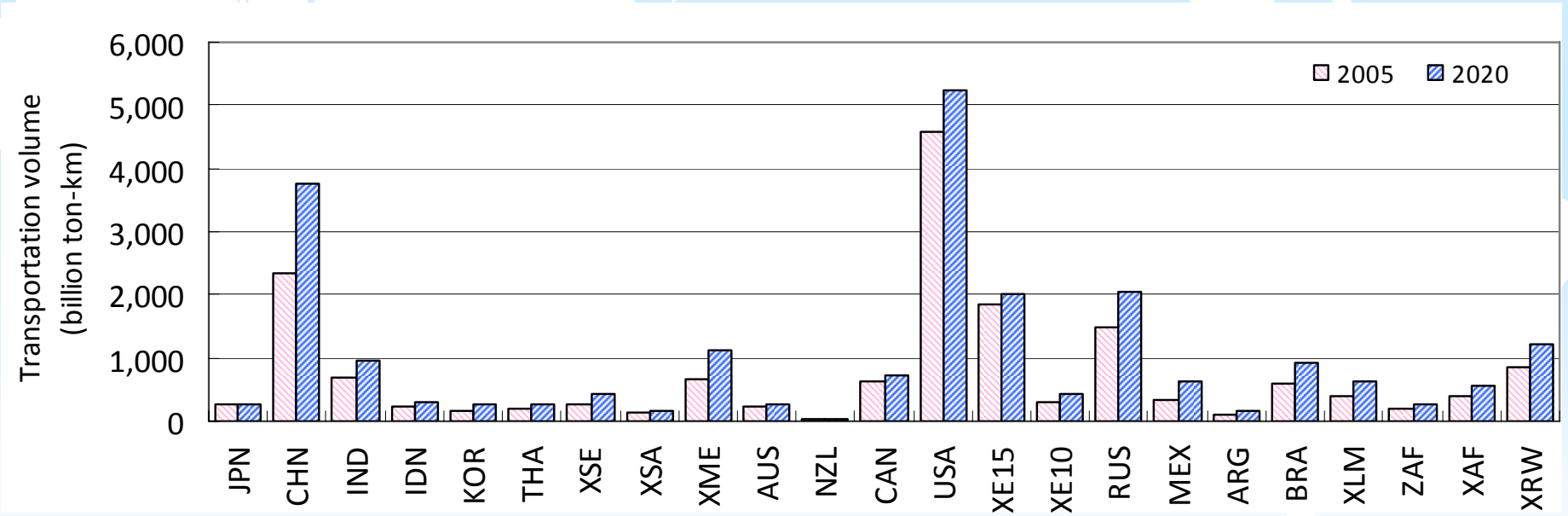


- **Annual growth rate of passenger transport from 2005 to 2020**

	JPN	CHN	IND	IDN	KOR	USA	XE15	XE10	RUS	BRA	World
'20/'05	-0.1%	3.0%	2.1%	1.6%	4.2%	1.0%	1.2%	2.7%	2.0%	2.8%	1.8%

Freight Transportation Demand model

- **In the freight transportation demand model, net freight transportation volume is estimated by multiplying population by net transportation volume per capita, and transport share is estimated by per capita GDP, thus transportation volume in different transportation mode are determined by multiplying net transportation volume by transport share.**

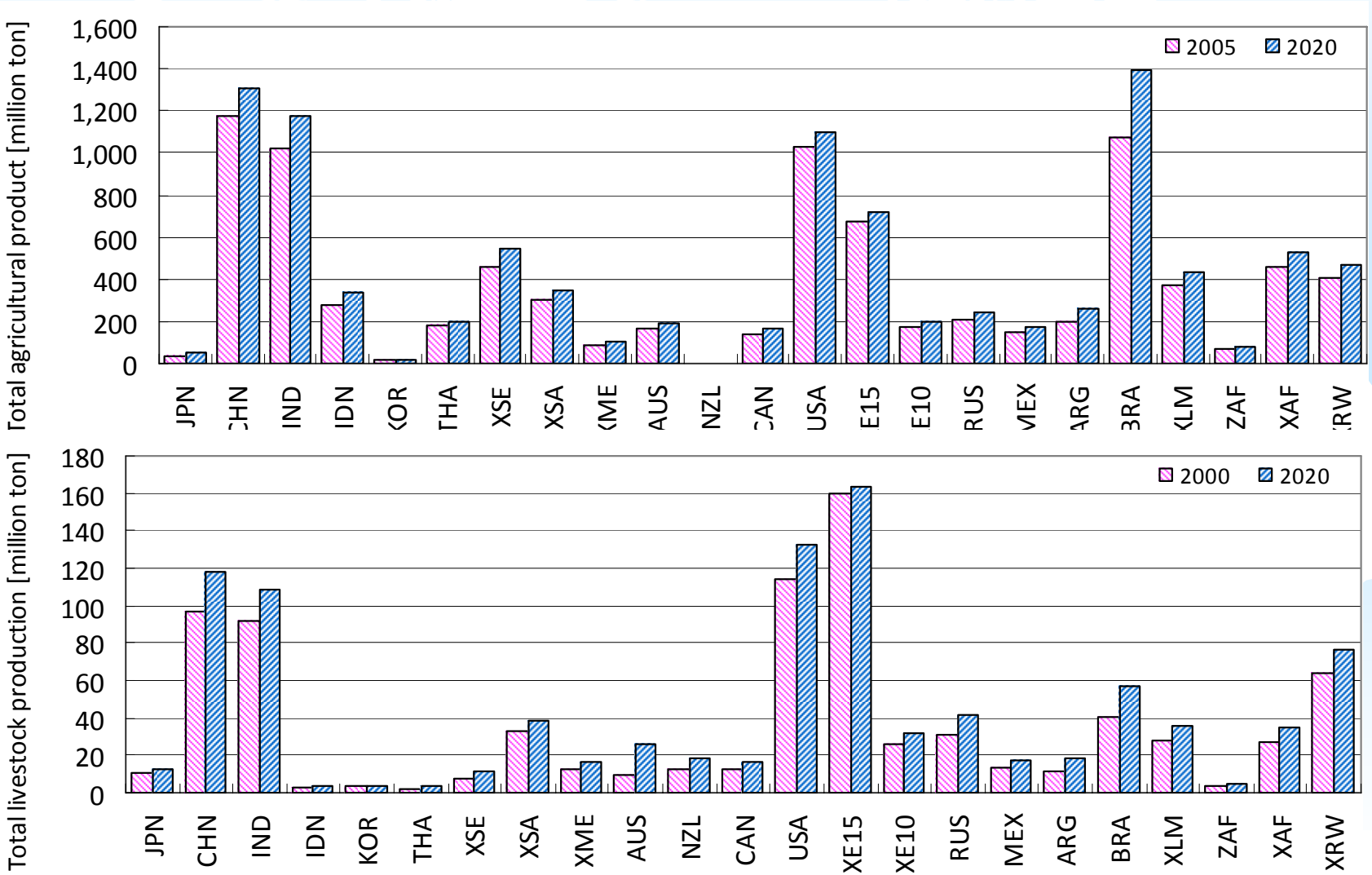


- **Annual growth rate of freight transport from 2005 to 2020**

	JPN	CHN	IND	IDN	KOR	USA	XE15	XE10	RUS	BRA	World
'20/'05	-0.2%	3.2%	2.2%	1.7%	2.6%	0.9%	0.6%	2.6%	2.2%	2.9%	2.0%

Agriculture Trade model

- **Agricultural products are estimated by the Agriculture Trade model.**



Baseline assumption & technologies

Baseline assumption

Baseline is set as a technology frozen case, i.e. when the future share and energy efficiency of standard technologies are fixed at the same level as in the base year.

Mitigation technologies

This study is based on realistic and currently existing technologies, and future innovative technologies expected in 2020 are not taken into account.

Note1）For example, CCS is one of expected future innovative technologies that is likely to have large effect on mitigation measures. due to the lack of data availability, CCS is not taken into account as a mitigation measure in this study.

Note2) Effects of mitigation measures such as additional policies promoting modal shift, public-enlightment actions are not considered in this study.

Overview of this study

Mitigation potentials in this study are defined as follows:

Reduction amounts which are estimated by comparing the effect of introduction of new mitigation technologies in the target year, target region and target sector as compared to the effect of standard technologies fixed at the same level as in the base year

- **Target Regions : 23 geographical world regions**
- **Time Horizon : 2000 – 2020**
- **Target Gas : CO_2, CH_4, N_2O, HFCs, PFCs, SF_6**
- **Target Sectors : multiple sectors**
  (Power generation / Industry / Residential and Commercial / Fugitive/ Transport / Agriculture / Waste / F-gas emissions sector)

Technology database **Energy Database**

Mitigation potentials in 2020 are estimated at a 5%/year discount rate by using MAC tool with detailed mitigation options database

Caveats of this study

The following points must be kept in mind while interpreting the results of this study:

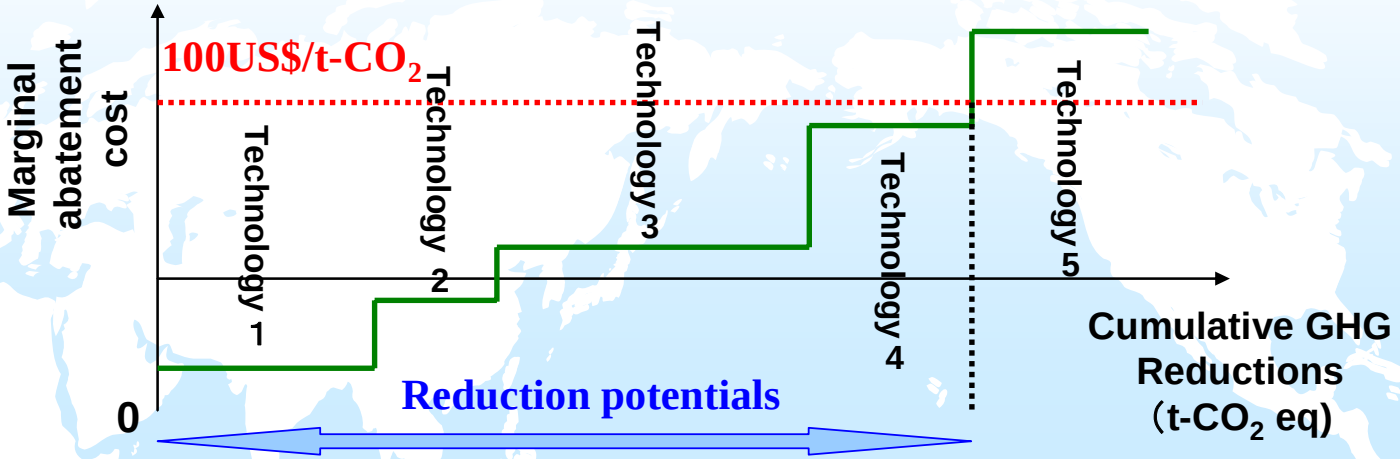
1) Possibility of more mitigation potentials

This study is based on realistic and currently existing technologies, and future innovative technologies expected in 2020 are not taken into account.. Therefore, it may be possible to reduce more if innovative technologies become available in the future.

2) Possibility of over estimation

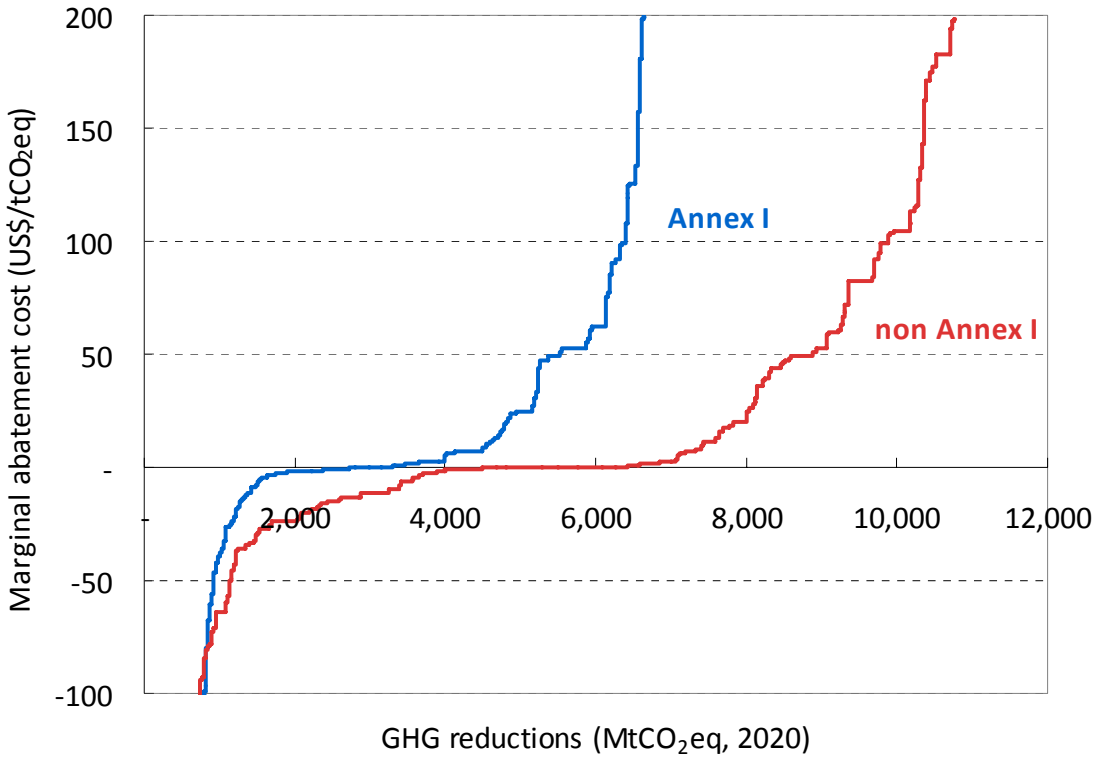
The baseline emissions in 2020 are estimated under the technology-frozen case which does not take into account changes in the industrial structure. Moreover, future service demands are exogenous parameters, thus changes in the industrial structure and service demands due to the effects of mitigation measures are not taken into account. Thus baseline emissions and reduction potentials may be overestimated.

Methodology of reduction potential estimates in this study



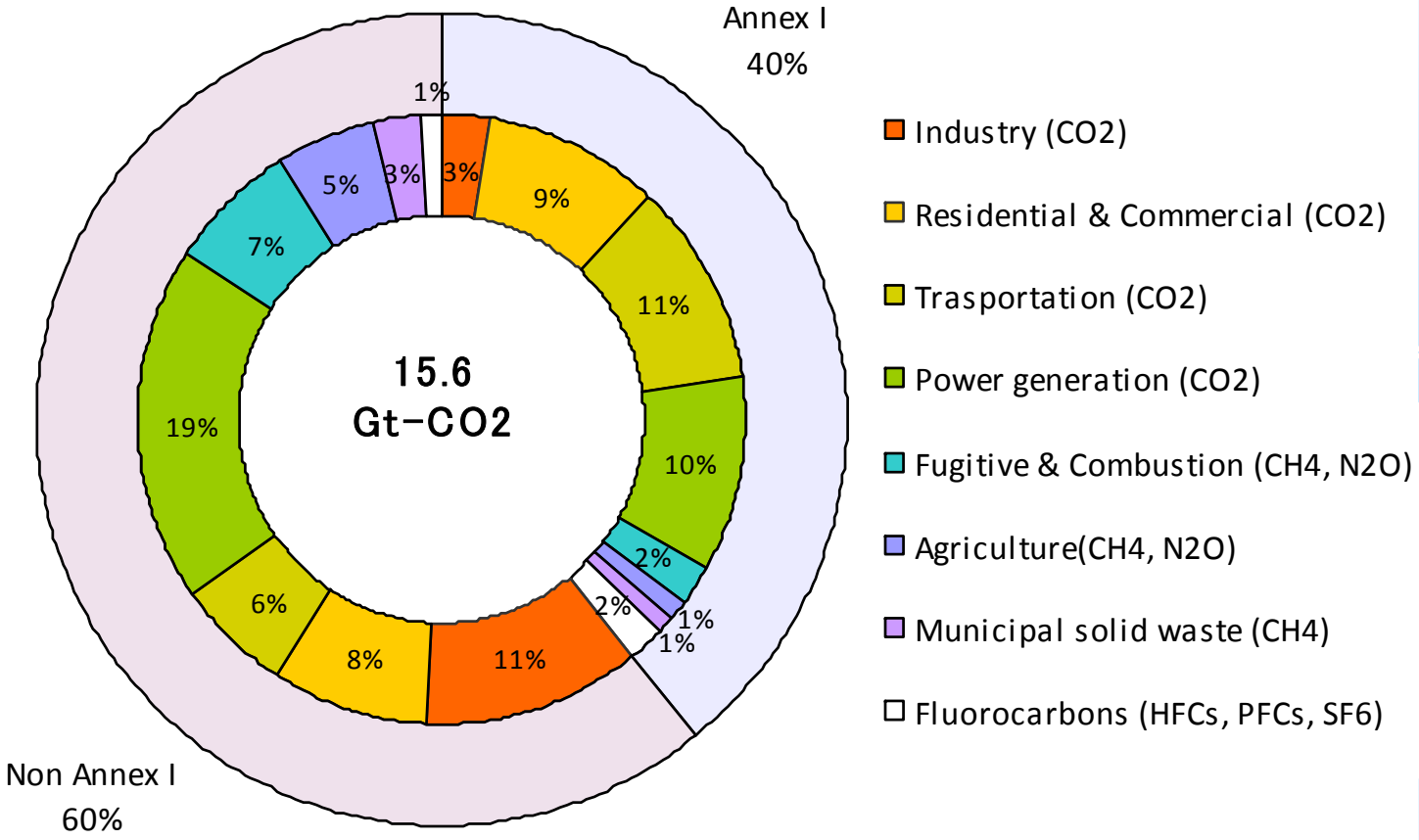
① Setting the level of standard technologies in the base year, target region and target sector.
② Setting technology database (initial & running costs, energy consumption, service supply per unit of technology, lifetime, diffusion rate, etc) and energy database (Energy type, energy price, emission factor, etc).
③ Setting activity amounts in the target year, target region and target sector.
④ For a mitigation technology *l* in each sector, calculating the GHG emission reduction per activity by introducing a technology *l*, additional cost of a technology *l*, and maximum potential of stock of a technology *l*, comparing with the standard technology.
⑤ Plotting abatement cost of unit reduction along the y-axis, and GHG emission reduction of a technology *l* along the x-axis in order of ascending abatement cost of unit reduction.
⑥ Cumulative GHG reductions under the 100US$/tCO$_2$ eq. are defined as "reduction potentials" in this study.

Marginal abatement cost curves in Annex I and Non-Annex I in 2020



- **Mitigation potentials in 2020 are estimated as 15.6 GtCO2 eq globally and 6.1 GtCO2 eq and 9.5 GtCO2 eq under 100 US$/tCO2 marginal abatement cost in 2020 in Annex I and Non- Annex I regions respectively.**
- **There are larger mitigation potentials for cost-effective measures in Non-Annex I. Thus international cooperation in technology transfers and financial assistance to developing countries may play an important role in achieving GHG mitigation.**

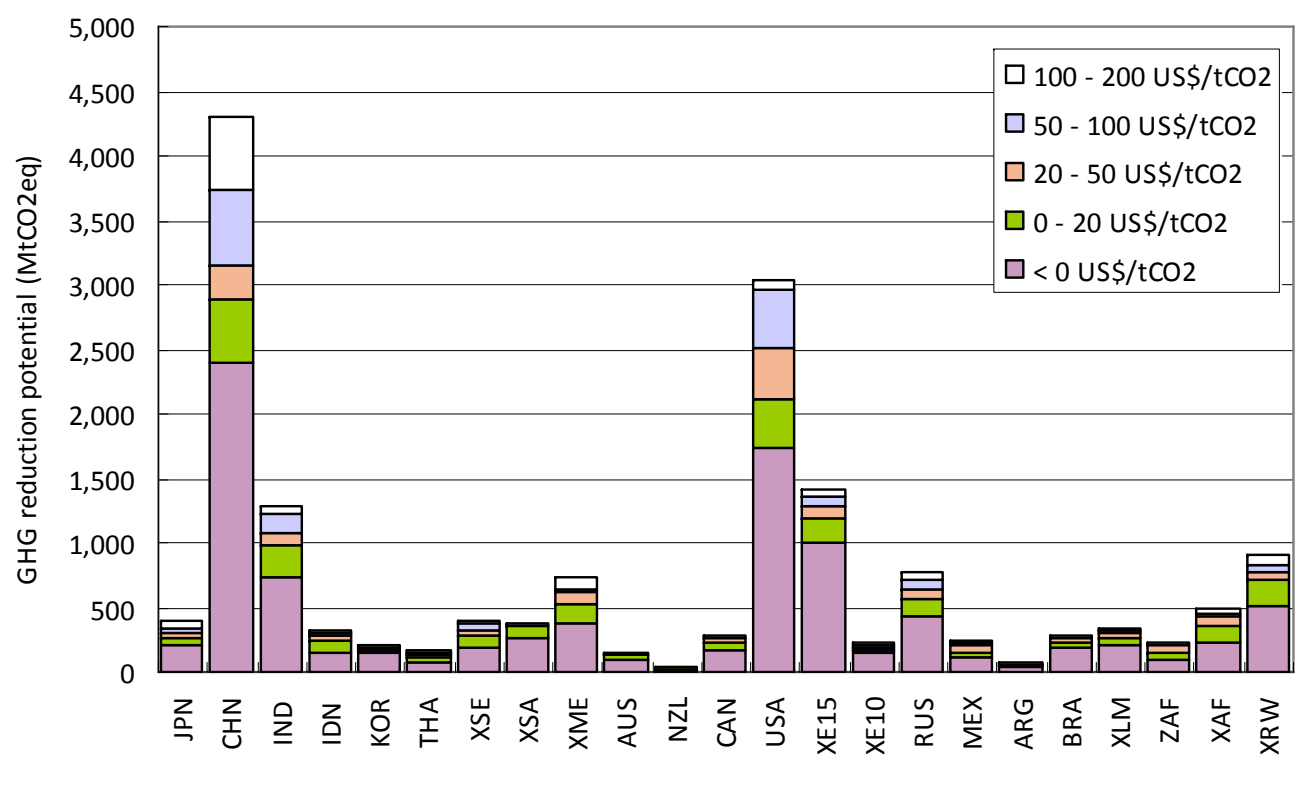
Ratio of sector-wise mitigation potentials in Annex I and Non-Annex I in 2020



- **Large mitigation potentials are identified in the power generation and industry sectors due to the use of low energy-efficient technologies in Non-Annex I regions. These sectors in A-I and NA-I account for about 40~50% of the total potential.**
- **Mitigation potentials in Non-Annex I account for about 60% of the total potential.**

Region-wise mitigation potentials in 2020 for different cost categories

Mitigation potentials from 0 to 200 US$/tCO$_2$ at a 5%/year discount

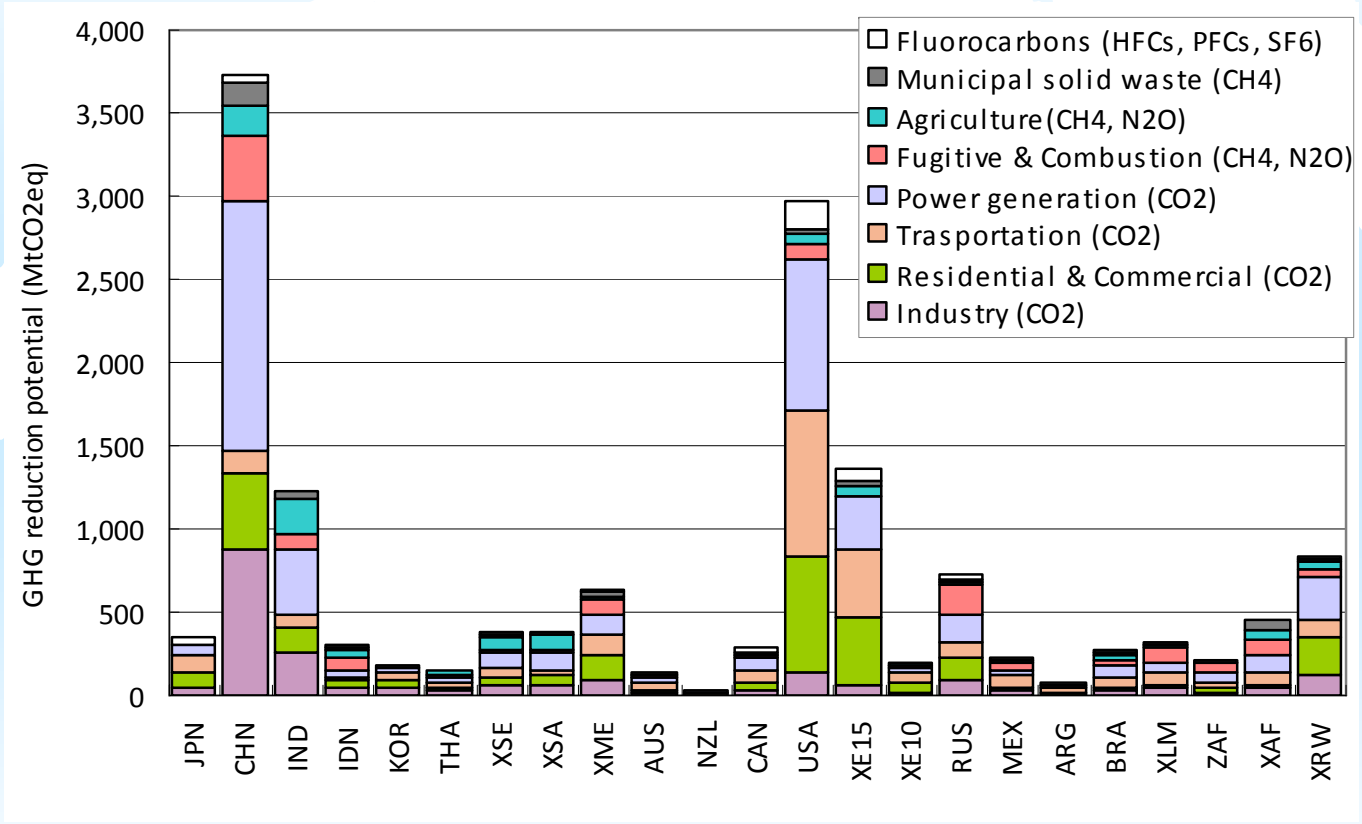


JPN	Japan
CHN	China
IND	India
IDN	Indonesia
KOR	Korea
THA	Thailand
XSE	Other South-east Asia
XSA	Other South Asia
XME	Middle East
AUS	Australia
NZL	New Zealand
CAN	Canada
USA	USA
XE15	Western Europe(15)
XE10	Eastern Europe(10)
RUS	Russia
ARG	Argentine
BRZ	Brazil
MEX	Mexico
XLM	Other Latin America
ZAF	South Africa
XAF	Other Africa
XRW	Rest of the World

- **China, US, India, Western Europe and Russia are five major regions with large reduction potentials, accounting for approximately 60% of the total reduction potential in the world. Ten major regions account for approximately 75%.**
- **It is important to think carefully about the meaning of the no-regret (i.e. 0US$/tCO2 eq.) case . Even if it is no-regret, such options cannot be introduced without imposing initial costs.**

Sector-wise mitigation potentials in 2020

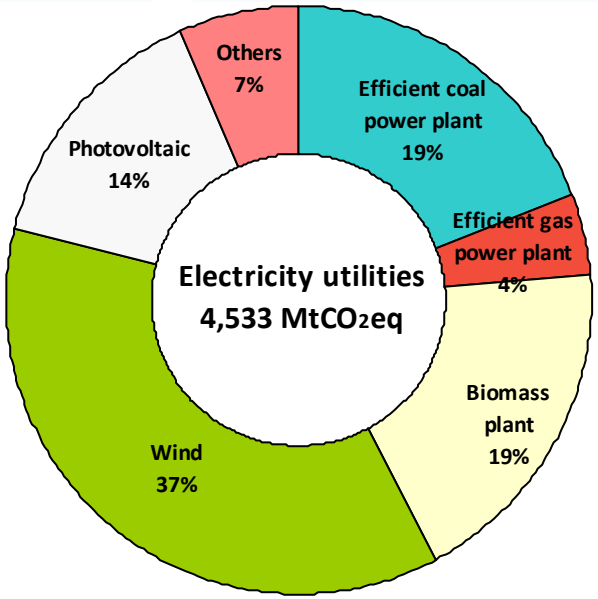
Mitigation potentials under 100 US$/tCO$_2$ at a 5%/year discount rate

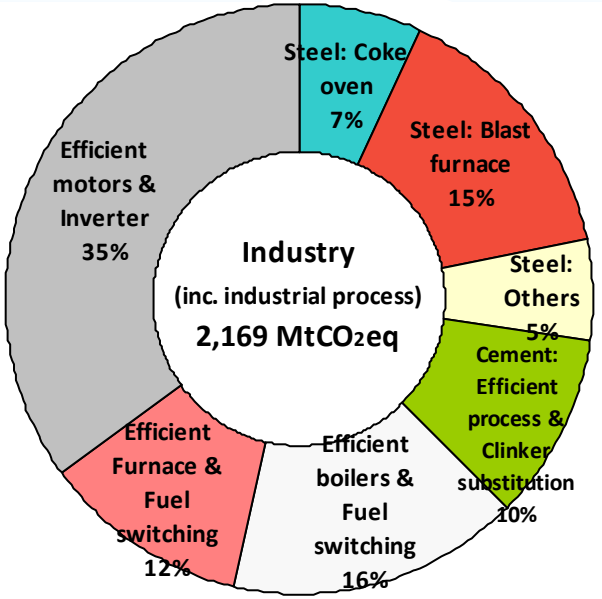


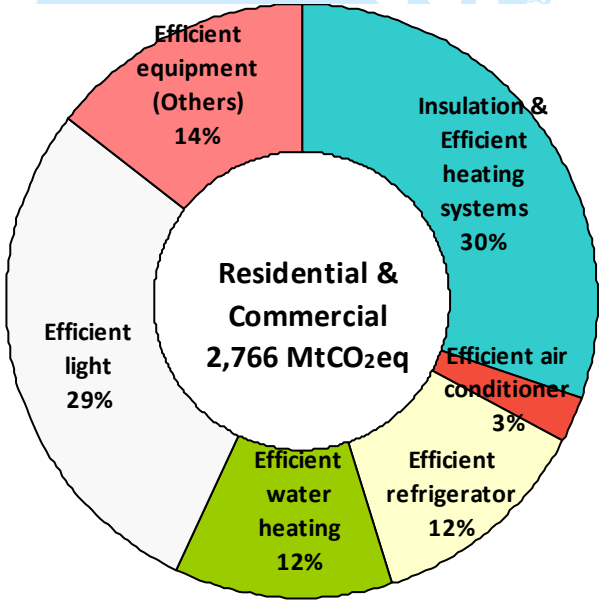
JPN	Japan
CHN	China
IND	India
IDN	Indonesia
KOR	Korea
THA	Thailand
XSE	Other South-east Asia
XSA	Other South Asia
XME	Middle East
AUS	Australia
NZL	New Zealand
CAN	Canada
USA	USA
XE15	Western Europe(15)
XE10	Eastern Europe(10)
RUS	Russia
ARG	Argentine
BRZ	Brazil
MEX	Mexico
XLM	Other Latin America
ZAF	South Africa
XAF	Other Africa
XRW	Rest of the World

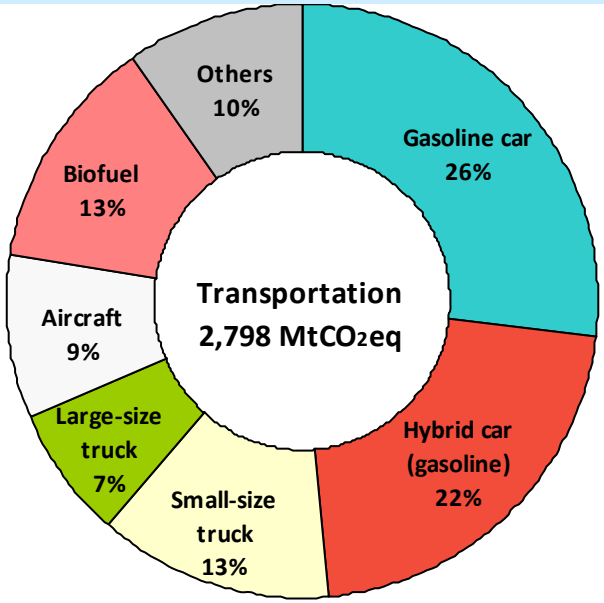
- **In China and India with high economic growth, reduction measures in industry and power generation sectors are significant. In developing countries, it is also effective to reduce emissions from agriculture and waste sectors.**
- **In developed countries, it is important to undertake measures in the industry and power generation sectors, but potentials in transport, residential and commercial sectors are also large.**

Major Mitigation Option

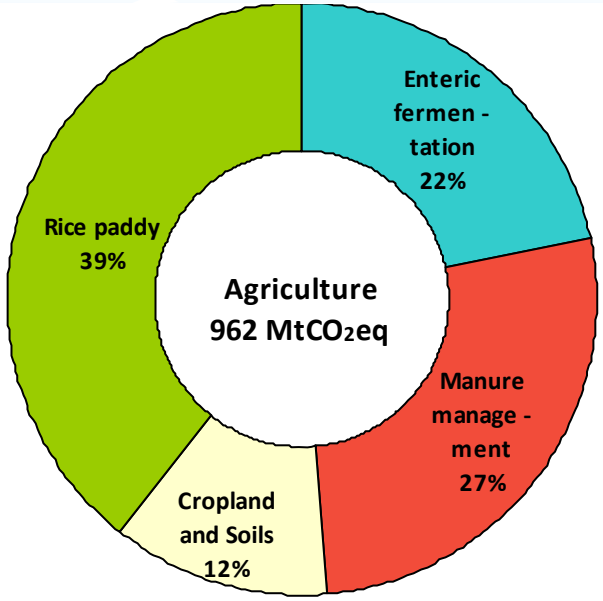


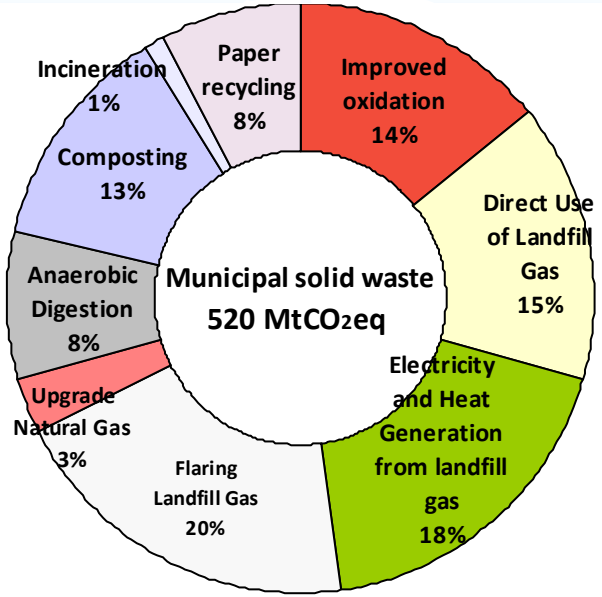


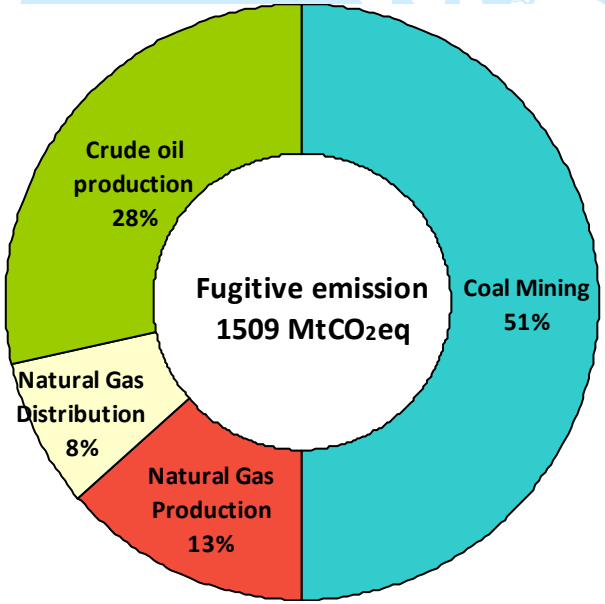


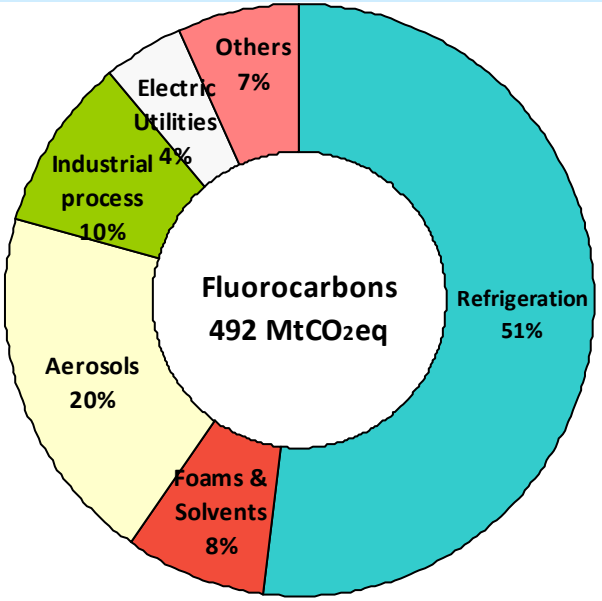


Major Mitigation Option

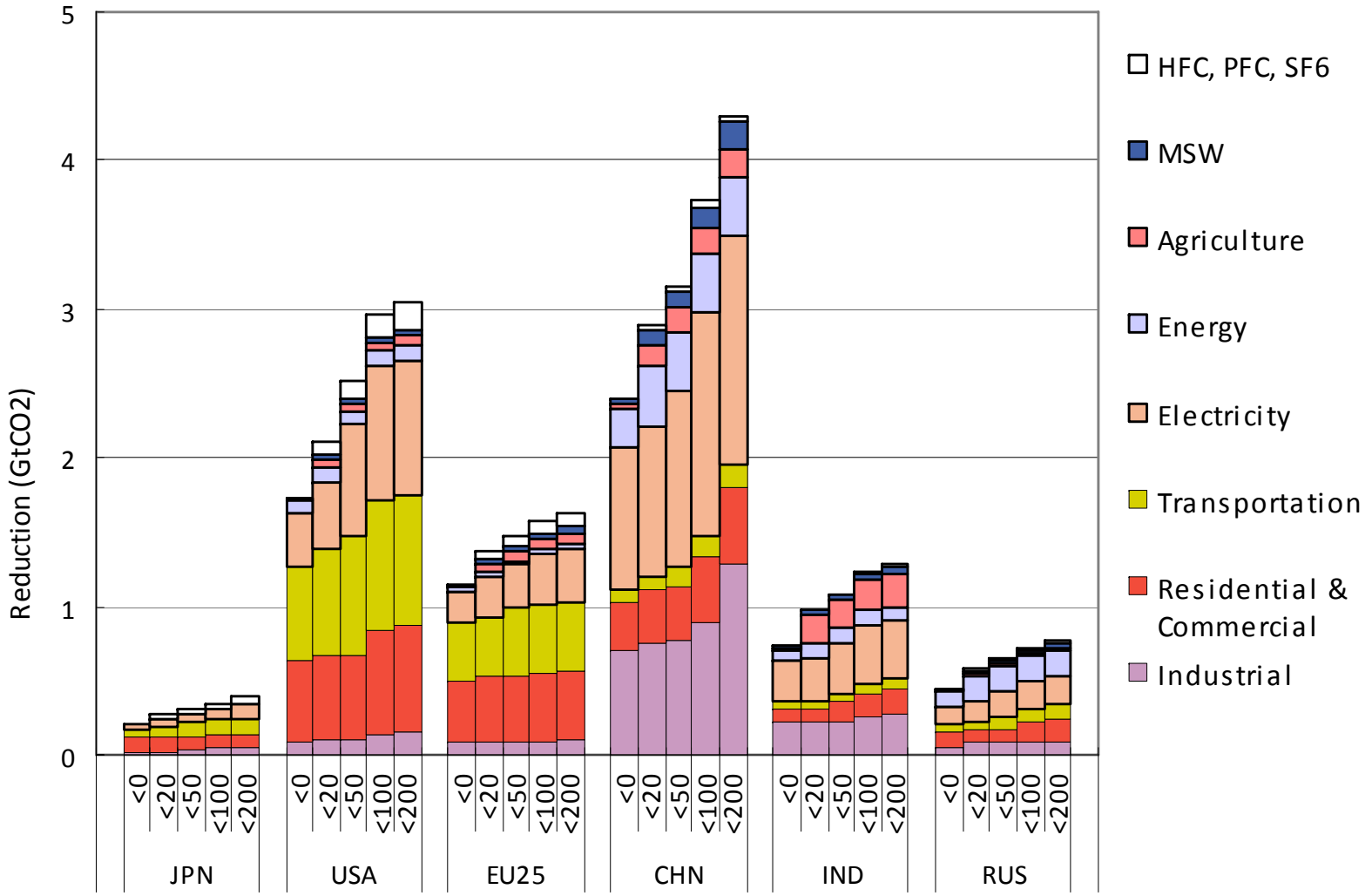




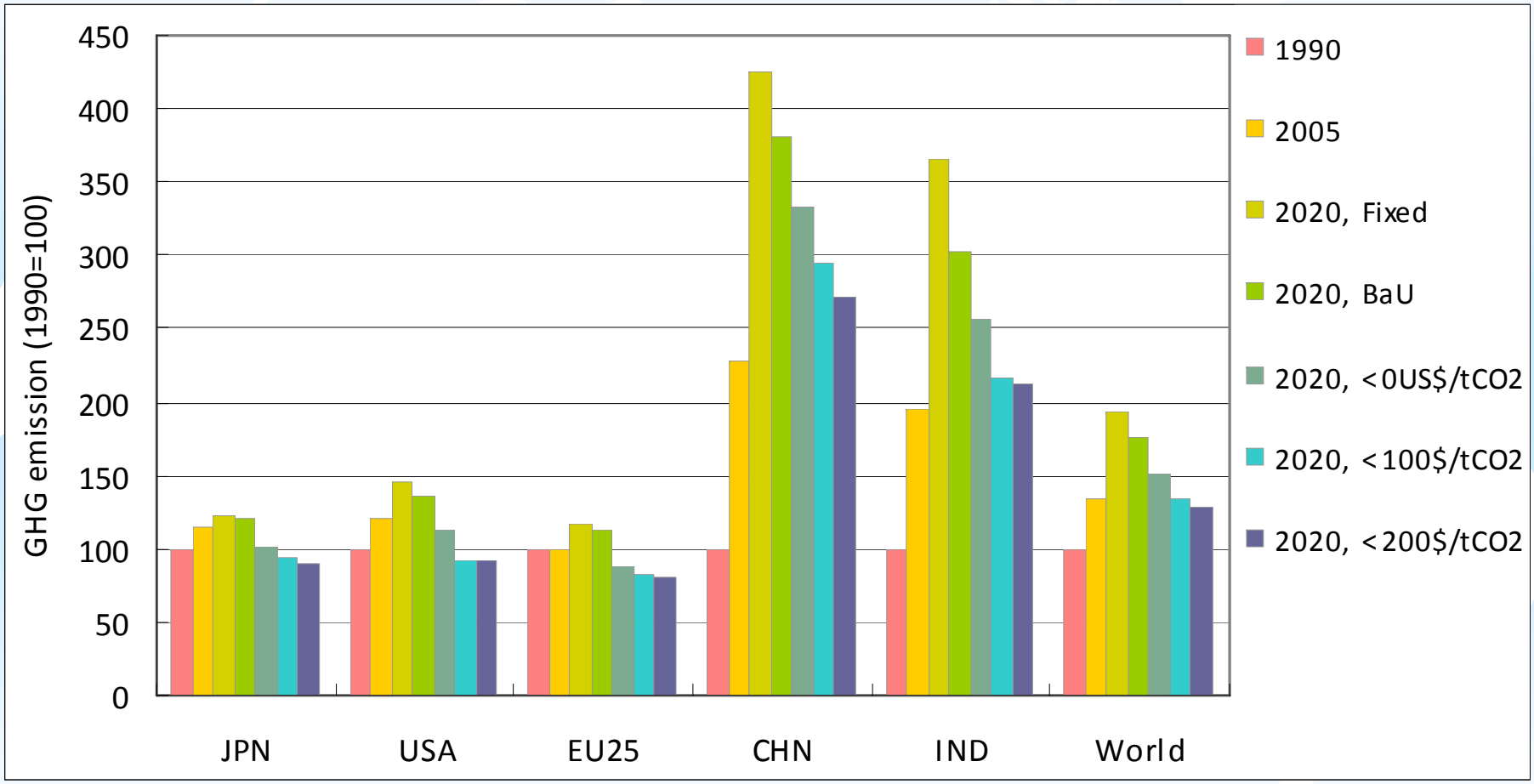




Sector-wise potentials in major countries and regions for different cost categories



Emission in 2020 for different cost categories
- How do you define the BaU? -



- **In this study, reduction potentials are estimated compared to the technology-frozen case. However, if we define a certain BaU not the technology-frozen case, then the results of mitigation potentials become different, especially under the no-regret case.**

GHG Emissions in major countries & regions

Unit: $GtCO_2$ eq

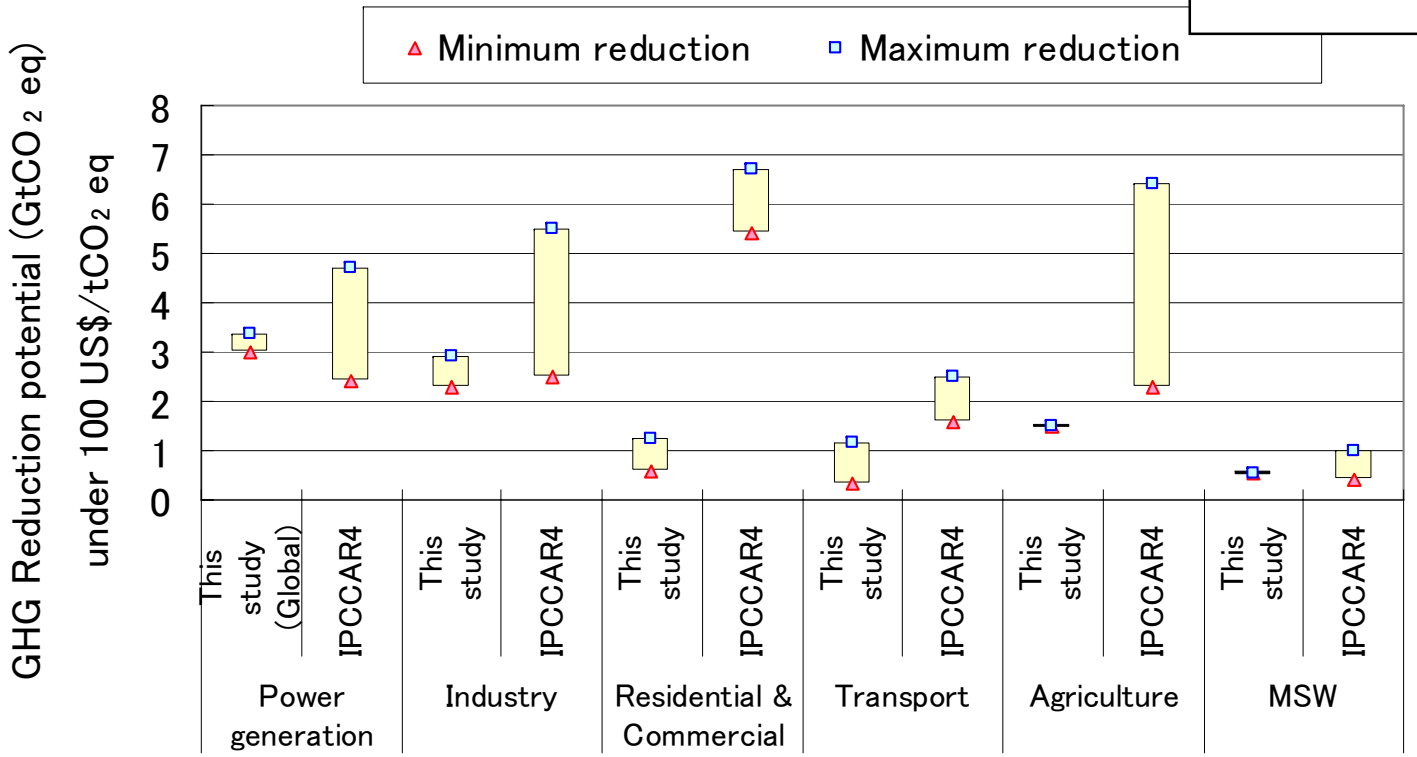
				2020 (Mitigation)					
	1990	2005	2020 (Frozen)	< 100 $/tCO2	vs 1990	vs 2005	< 200 $/tCO2	vs 1990	vs 2005
Japan	1.25	1.41	1.53	1.13～1.18	−9 % ～ −5 %	−19 %～ −16 %	1.11～1.14	−11 % ～ −9 %	−21 % ～ −19 %
US	6.33	7.28	8.92	5.84～5.96	−8 % ～ −6 %	−20 % ～ −18 %	5.77～5.88	−9 % ～ −7 %	−21 % ～ −19 %
EU25	5.09	4.98	5.80	4.14～4.22	−19 % ～ −17 %	−17 % ～ −15 %	4.10～4.17	−20 % ～ −18 %	−18 % ～ −16 %
China	3.74	7.53	12.78	8.76～8.91	134 % ～ 138 %	16 % ～ 18 %	8.22～8.33	120 % ～ 123 %	9 % ～ 11 %
India	1.48	2.38	3.55	2.36～2.40	59 % ～ 61 %	−1 % ～ 1 %	2.31～2.35	55 % ～ 58 %	−3 % ～ −1 %
Russia	3.07	2.21	2.80	2.05～2.07	−33 % ～ −32 %	−7 % ～ −6 %	2.00～2.02	−35 % ～ −34 %	−9 % ～ −8 %
Annex I	16.89	17.31	20.84	14.49～14.77	−14 % ～ −13 %	−16 % ～ −15 %	14.27～14.52	−15 % ～ −14 %	−18 % ～ −16 %
Non Annex I	16.32	25.02	36.15	26.43～26.77	62 % ～ 64 %	6 % ～ 7 %	25.45～25.77	56 % ～ 58 %	2 % ～ 3 %
Global	33.86	43.29	58.25	42..00～42.62	24 % ～ 26 %	−3 % ～ −2 %	40..80～41.37	20 % ～ 22 %	−6 % ～ −4 %

- **Mitigation measures based on realistic and currently existing technologies are not enough to reduce GHG emissions, and changes in the industrial structure and service demands are also required to achieve the Low Carbon Society. .**

Comparison with the IPCC AR4

Mitigation potentials under 100US$/t-$CO_2$

Previous study

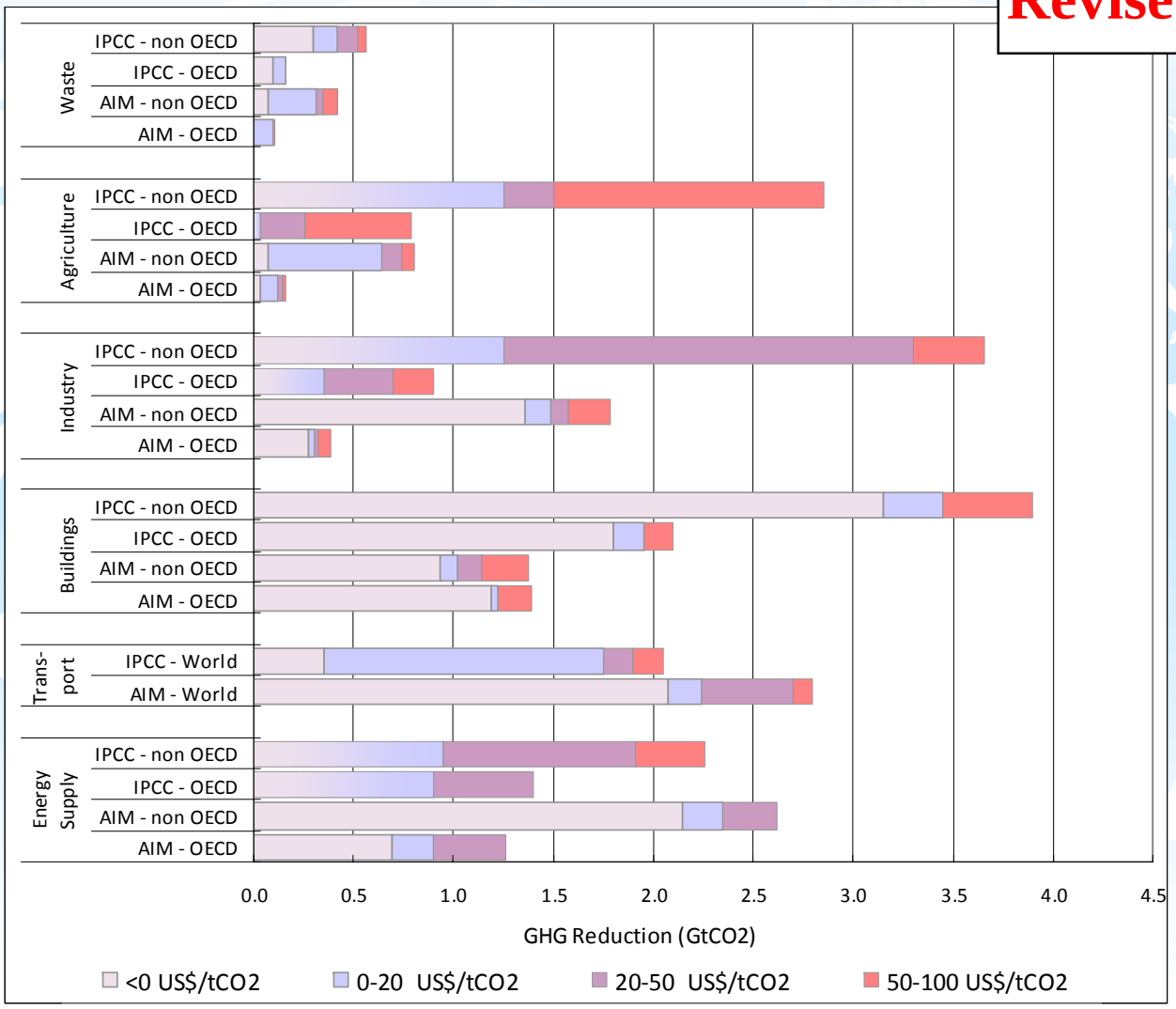


- **This study shows results for 2020, but results in IPCC AR4 are for 2030.**
- **The amount of potentials in IPCC AR4 are larger than this study, not only because IPCC AR4 focuses on different year and so estimated activity levels are different, but also because its coverage of mitigation options are wider than this study.**

Comparison with the IPCC AR4

Mitigation potentials under 100US$/t-$CO_2$

Revised version



- **This study shows results for 2020, but results in IPCC AR4 are for 2030.**

Summary

1. **Reduction potentials in 2020 are estimated as 15.6 GtCO2 eq, 6.1 GtCO2 eq and 9.5 GtCO2 eq in global, Annex I and Non-Annex I respectively under 100 US$/tCO2 marginal abatement cost in 2020.**
2. **China, US, India, Western Europe and Russia are five major regions where there are large reduction potentials, and account for about 60% of the total reduction potential, and top ten major regions account for about 75 %.**
3. **The major sectors which have large reduction potentials vary depending on the socio-economic characteristics of each region. In general, large reduction potentials exist in power generation and industry due to the use of low energy-efficient technologies especially in Non-Annex I countries, and these sectors account for approximately 40% of total global reduction potential.**
4. **There is a much larger potential for cost-effective measures in developing countries, therefore international cooperation such as technology transfer and financial assistance to developing countries will play an important role.**
5. **In order to promote drastic GHG reductions, it is important to think of not only efficiency improvement of current technologies but also the future innovations and changes of social structure towards the Low Carbon Society.**

Thank you