Greenhouse Gas Emissions Technical Mitigation Potentials and Costs in 2020 (second edition)

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Workshop on mitigation potentials, comparability of efforts and sectoral approaches
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Key Questions ①

- **How to estimate mitigation potentials?**
- **How much is mitigation potential by region and by sector in 2020?**
- What kinds of barriers exit to prevent such potential into practice?
  - Financing, public acceptance, lack of information, lack of incentives/ability
- What kinds of policies are effective to support implementation of mitigation technologies?

and so on

Key Questions ②

How and why difficult to estimate mitigation potentials?

- Difficulty in getting information on technology vintages of the base year by region
- Difficulty in assuming characteristics of technologies in future
  - Performance & efficiency improvement
  - Initial cost, running cost, other incremental costs
- Uncertainties of driving forces (e.g. population, GDP, energy price)
  - Economic situation
  - Level of activities caused by lifestyle, political situation, international relationships, etc.

Key Questions ③

What are important points when comparing results of mitigation potentials estimated by different models?

Coverage

1) Geographical coverage
2) Sectoral coverage
3) GHG coverage
4) Mitigation options coverage

Definition

1) Definition of "potential"
2) Definition of "cost"
3) Definition of "drivers"
4) Definition of any specific terms…

Data assumptions

1) Population
2) GDP and service demands
3) Energy price
4) Discount rate
5) Baseline scenario

Detail information (which reflects key uncertainties)

1) The rate of technology development and diffusion
2) The cost of future technology
3) Climate and non-climate policy drivers

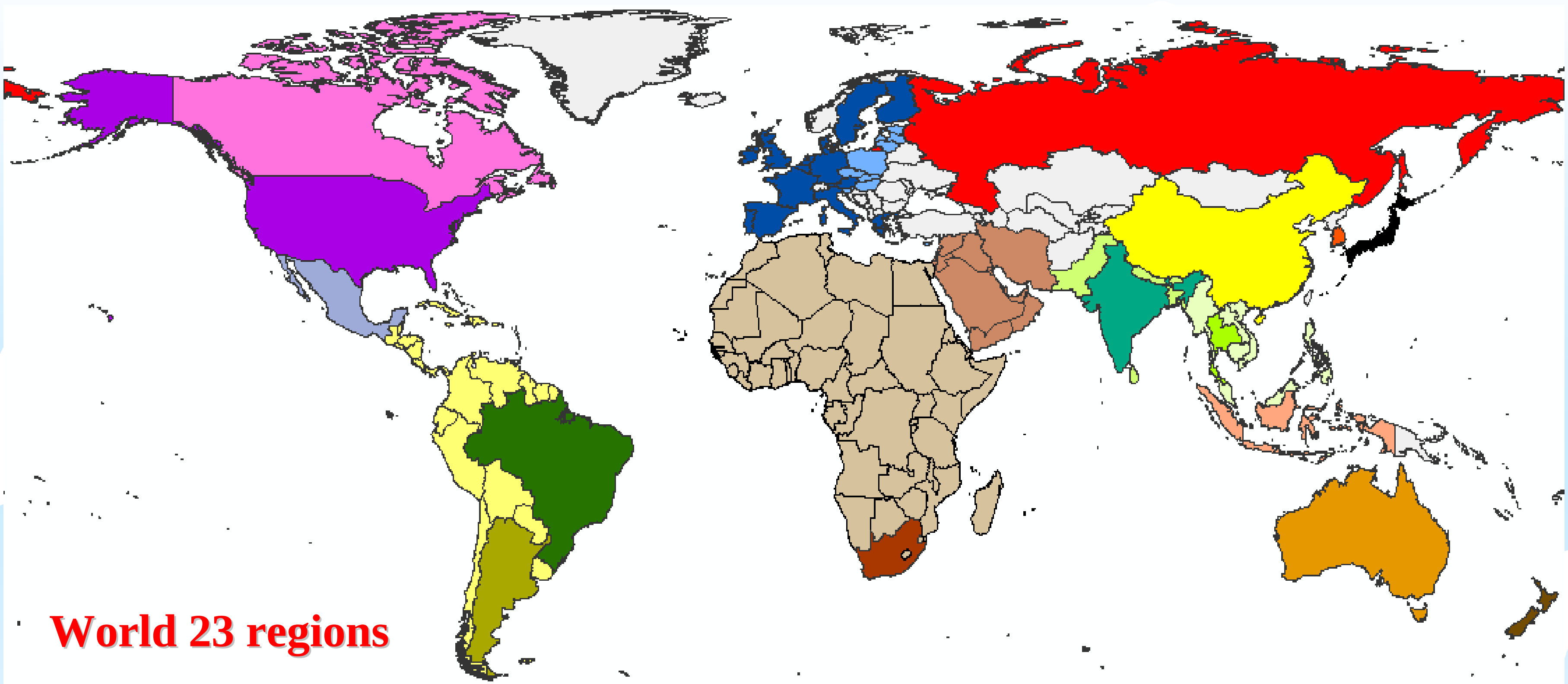
…. And so on

Objective of study

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

Regional Classification



- JPN (Japan)
- CHN (China)
- IND (India)
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- XSE (Other South-east Asia)
- XSA (Other South Asia)
- XME (Middle East)
- AUS (Australia)
- NZL (New Zealand)
- CAN (Canada)
- USA (United States)
- XE15 (EU15 in Western EU)
- XE10 (EU10 in Eastern EU)
- RUS (Russia)
- ARG (Argentina)
- BRA (Brazil)
- MEX (Mexico)
- XLM (Other Latin America)
- ZAF (South Africa)
- XAF (Other Africa)
- XRW (Rest of the World)

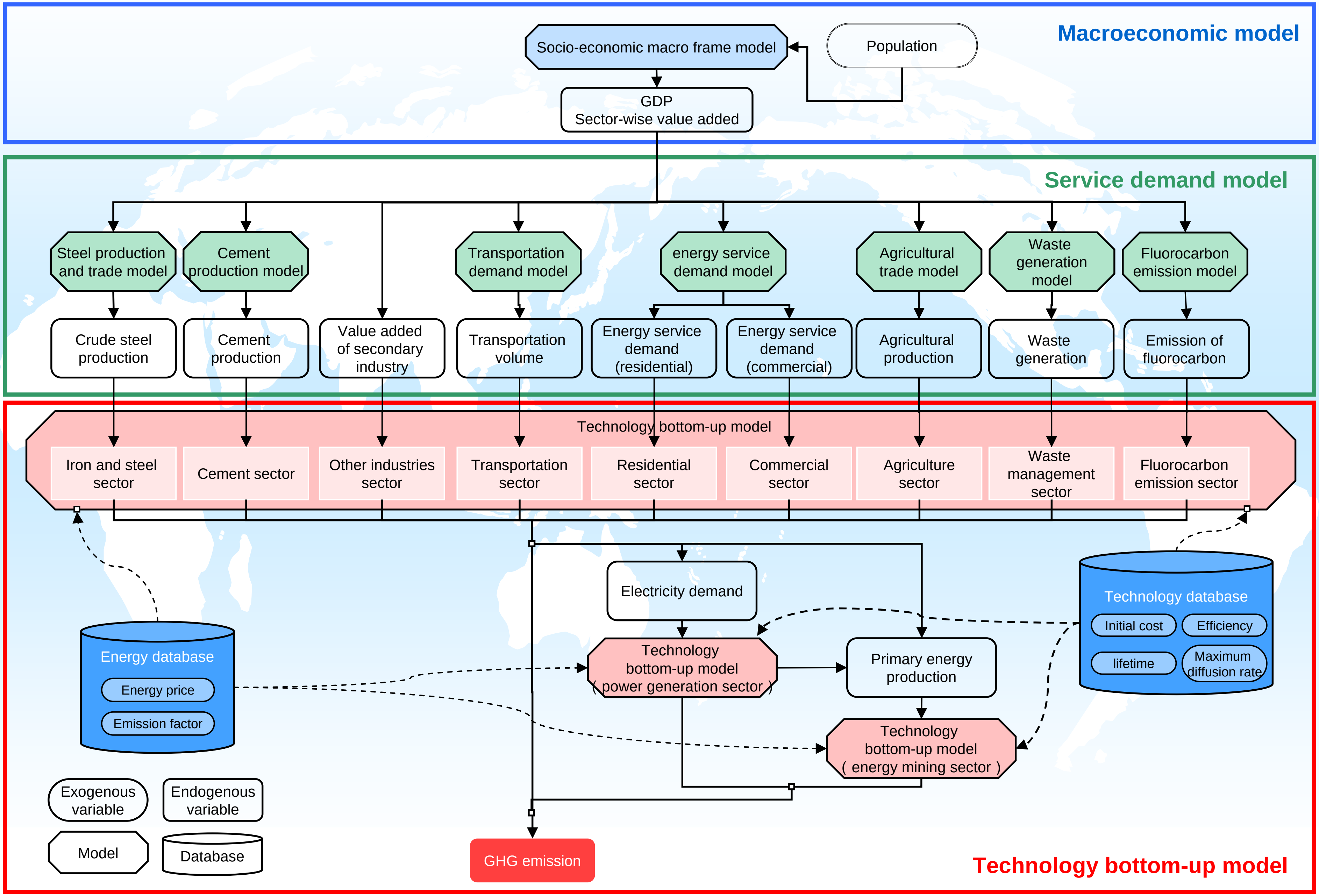
Developed countries

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 and & Commercial	Cooling, Heating, Hot-water ，Cooking ，Lighting ，Refrigerator, TV (only residential)
CH_4 N_2O	Agriculture	Livestock rumination, Manure management, Paddy field, Cropland
	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.

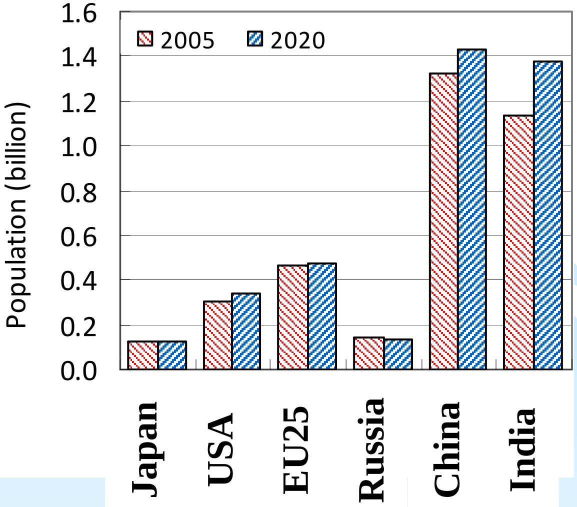
- Nuclear power plant is included in the base line but it is not considered as a mitigation option in this study.
- There are some sectors which are not able to be considered in this study due to the lack of data availability, for example, CO2 mitigation options in petrochemical sector, N2O mitigation options in chemical sector, N2O from waste water sector.

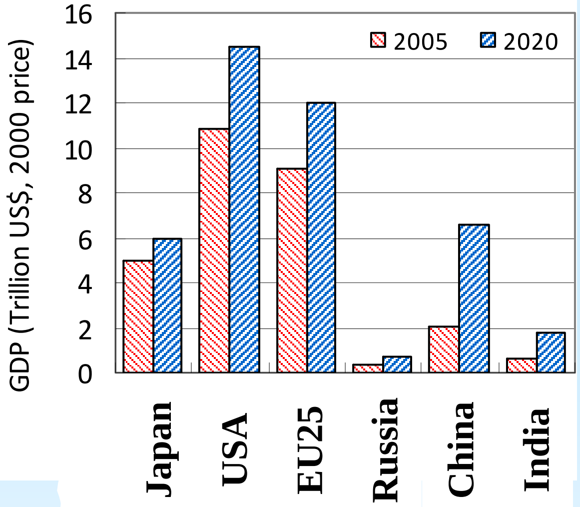
Overview of AIM/Enduse[Global]

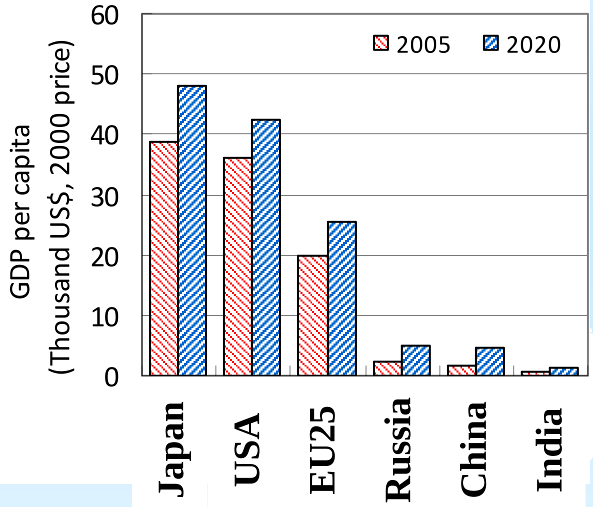


Socio-economic settings (POP and GDP)

- Population (POP)： the prospects at medium variant by UN World Population Prospects 2007
- GDP：GDP by region are estimated by the Socio-economic Macro Frame model .





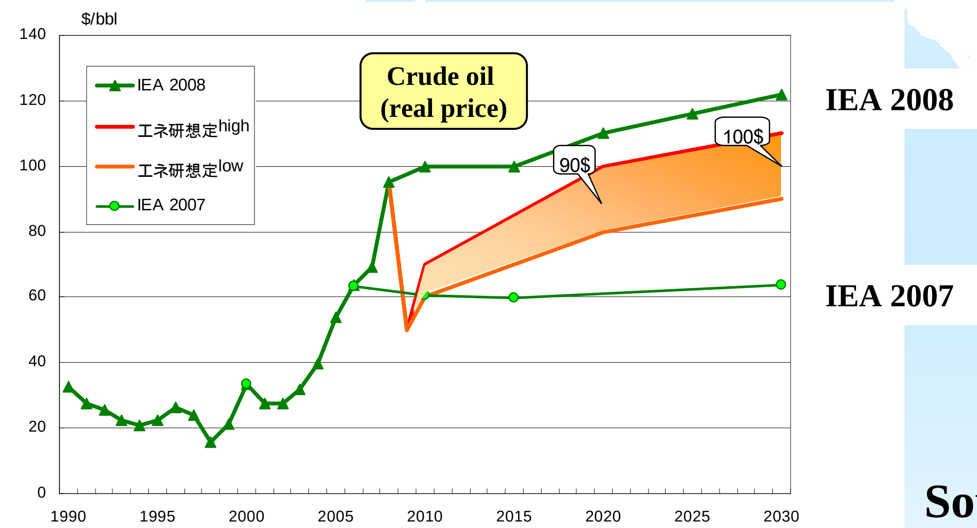


➢ **Annual growth rate from 2005 to 2020 (%/year)**

	Japan	USA	EU25	Russia	China	India	Developed	Developing	Global
POP	-0.2%	0.9%	0.1%	-0.6%	0.5%	1.3%	0.3%	1.2%	1.1%
GDP	1.3%	1.9%	1.9%	5.0%	8.1%	7.3%	1.9%	5.5%	3.0%
GDP/POP	1.5%	1.0%	1.7%	5.5%	7.6%	6.0%	1.6%	4.2%	1.9%

Socio-economic settings (Energy Prices)

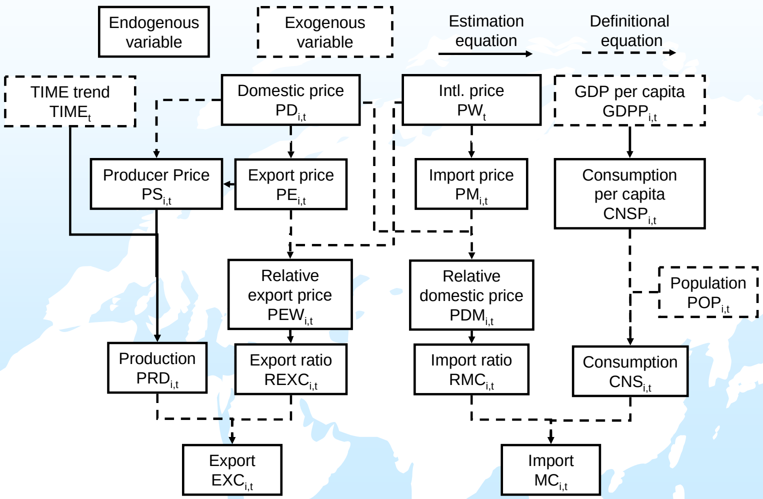
- Current domestic and international energy prices: IEA Energy Prices and Taxes (2007)
- Future international energy prices : assumptions made by the Institute of Energy Economics, Japan (personal communication, 2009), that lie between the estimates in IEA World Energy Outlook 2007 and IEA World Energy Outlook 2008 .



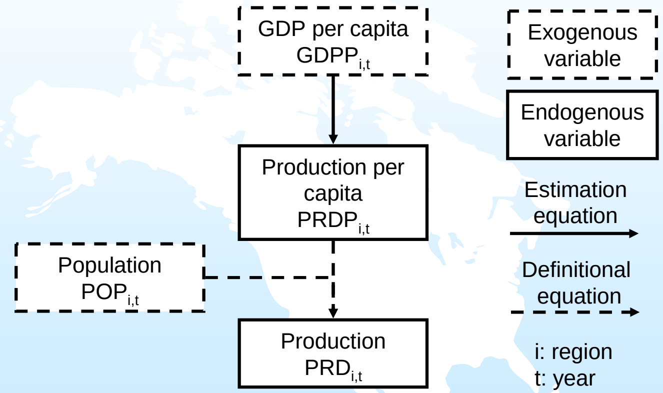
Source) IEEJ

Unit (real price)			2007	2020	2030
Crude oil		$/barrel	69.3	90	100
Gas	US	$/MBtu	6.8	11.2	13.5
	EU	$/MBtu	7.0	12.5	15.4
	Japan	$/MBtu	7.8	16.3	21.1
Coal		$/tonne	72.8	102.2	107.8

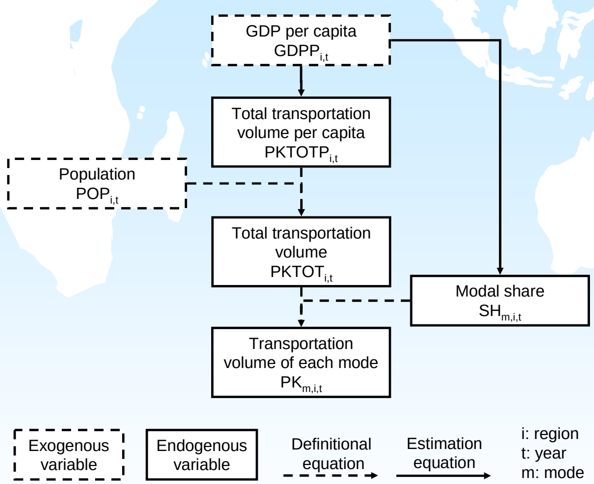
Service Demand Models

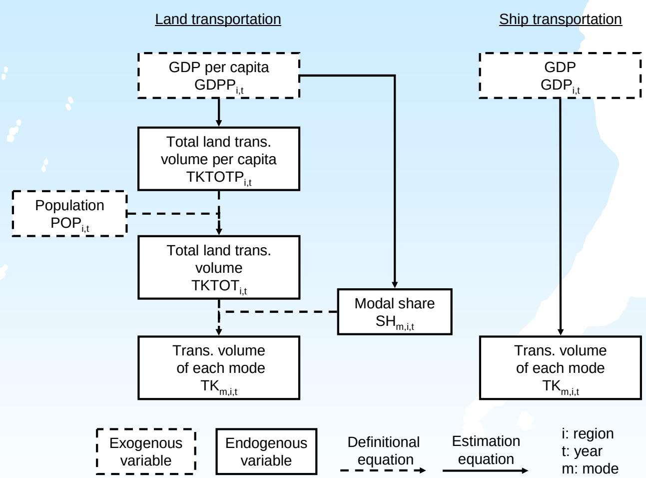


Steel production and trade model



Cement production model





Passenger transport demand model

Freight transport demand model

Service Demand Settings

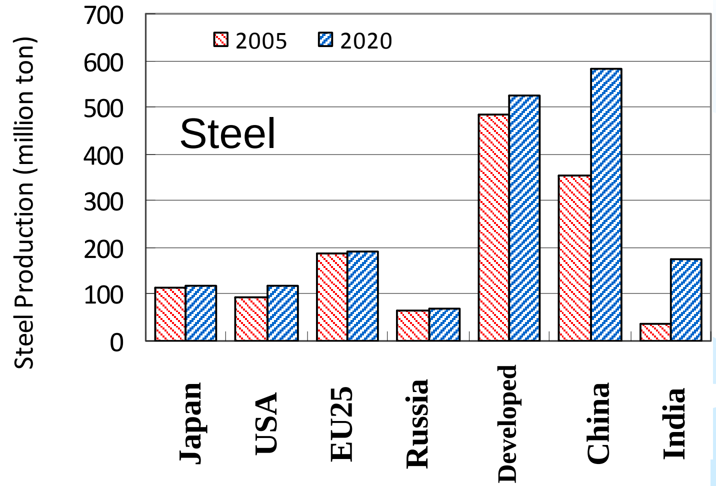
- Service demands are estimated by Steel production and trade model, Cement production model, Socio-economic macro frame model, Passenger transportation demand model, Freight transportation demand model, Agricultural trade model and so on. Data settings of GDP and population are the same across all sectors.
- service demands in each service and sector are estimated by these models based on various kinds of international and national statistics

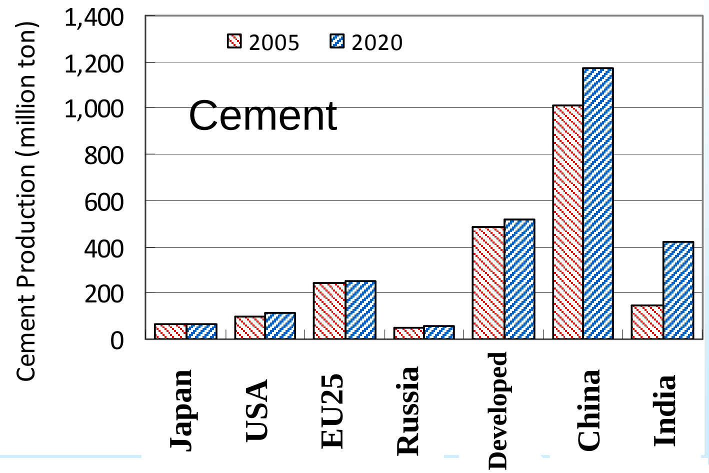
< Example of service demands in 2020 by major region >

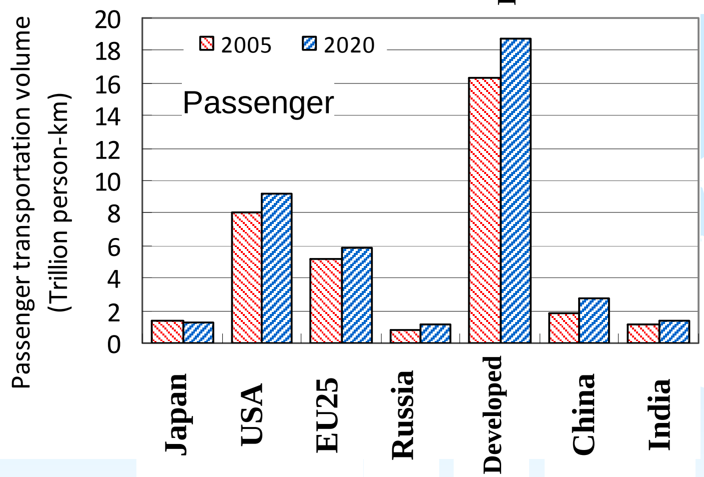
			Japan		USA		EU25		Russia	
			2005	2020	2005	2020	2005	2020	2005	2020
POP		Million	127.9	124.5	299.8	342.5	461.0	471.5	144.0	132.4
GDP		2000 US $	4.96	5.99	10.87	14.50	9.10	11.99	0.33	0.68
Industry	Steel	Million ton	112.5	119.7	94.2	119.3	187.3	190.7	66.1	69.0
	Cement	Million ton	68.7	66.7	100.0	113.1	242.5	252.3	48.7	59.2
	Others	2005 year=100	100	111	100	121	100	115	100	203
Transport	Passenger	Bil. p-km	1322.7	1243.7	8090.8	9233.7	5147.5	5884.3	833.3	1203.8
	Freight	Bil. ton-km	277.6	269.6	4583.9	5215.5	2161.8	2557.2	1473.1	1882.8

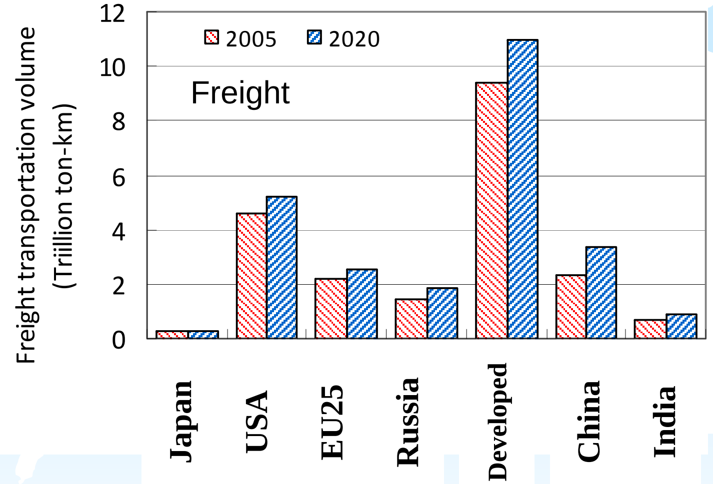
			China		India		Developing		Developed		World	
			2005	2020	2005	2020	2005	2020	2005	2020	2005	2020
POP		Million	1320.5	1429.8	1134.4	1379.2	5448.1	6555.3	1089.4	1135.5	6537.5	7690.8
GDP		2000 US $	2.02	6.54	0.61	1.77	9.19	20.62	26.59	35.11	35.78	55.74
Industry	Steel	Million ton	355.8	580.4	38.1	174.2	651.9	1097.2	484.8	526.1	1136.8	1623.3
	Cement	Million ton	1012.4	1175.0	142.7	417.9	1821.3	2673.8	483.5	518.5	2304.8	3192.2
	Others	2005 year=100	100	317	100	305	100	230	100	119	100	156
Transport	Passenger	Bil. p-km	1872.2	2763.8	1095.0	1408.4	9058.9	13661.2	16356.9	18724.4	25415.8	32385.6
	Freight	Bil. Ton-km	2338.7	3375.9	693.0	874.2	7573.8	10749.4	9382.1	10986.1	16955.8	21735.5

Service Demand Settings









- Annual growth rage from 2005 to 2020(%//year)

	Japan	USA	EU25	Russia	Developed	China	India	World
Steel	0.4%	1.5%	0.1%	0.3%	0.5%	3.3%	10.7%	2.4%
Cement	-0.2%	0.8%	0.3%	1.3%	0.5%	1.0%	7.4%	2.2%
Passenger	-0.4%	0.9%	0.9%	2.5%	0.9%	2.6%	1.7%	1.6%
Freight	-0.2%	0.9%	1.1%	1.6%	1.1%	2.5%	1.6%	1.7%

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 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:

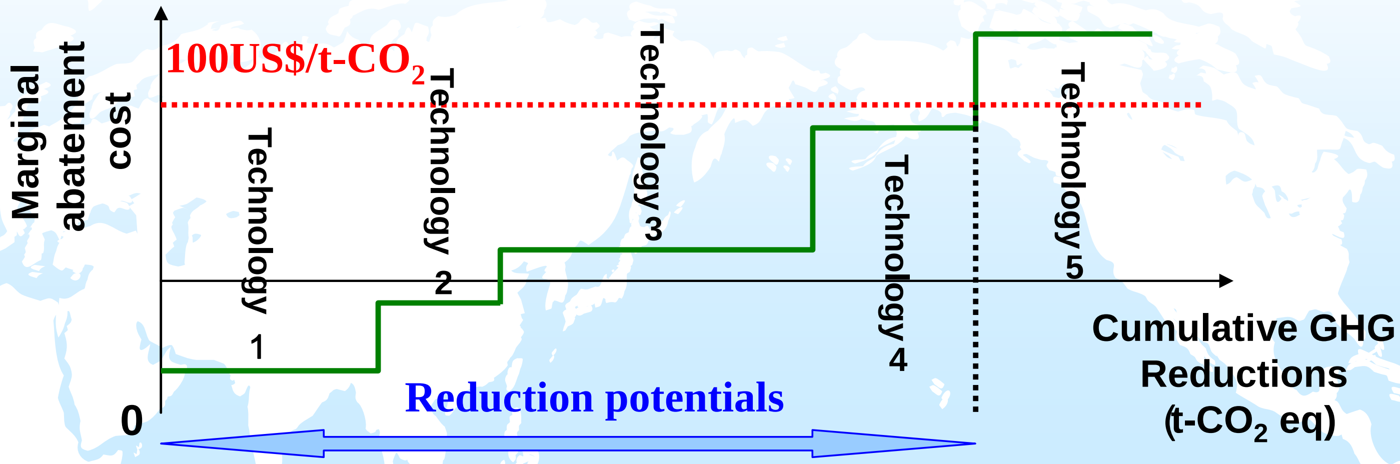
1) Possibility of more mitigation potentials

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.

Overview of Case Studies

Under the technology selection framework, energy efficient technology options are selected if energy saving cost benefits exceeds additional investment costs.

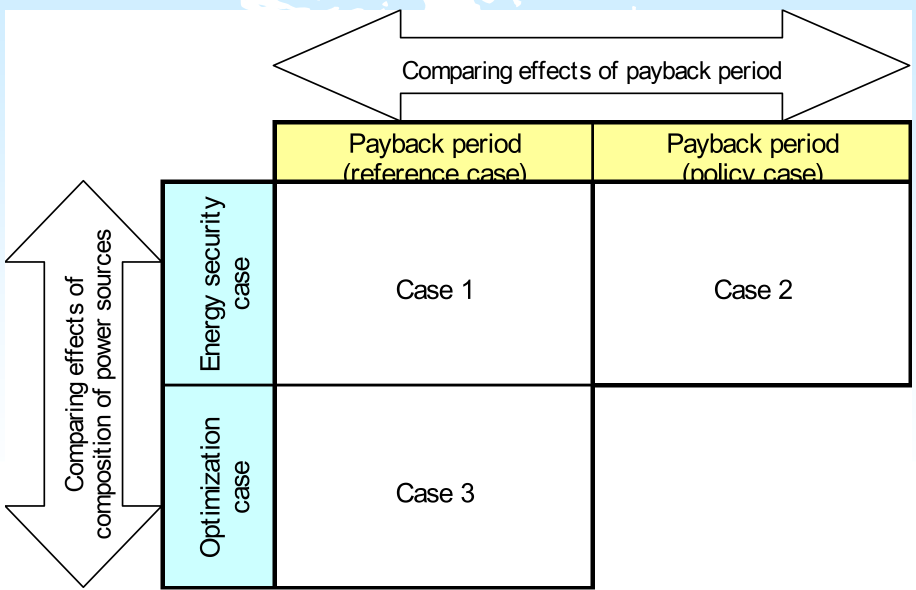
Additional investment cost
≦ energy savings × (energy price + emission factor × carbon price) × payback period

① Comparison of length of payback period (Case 1 and Case 2)

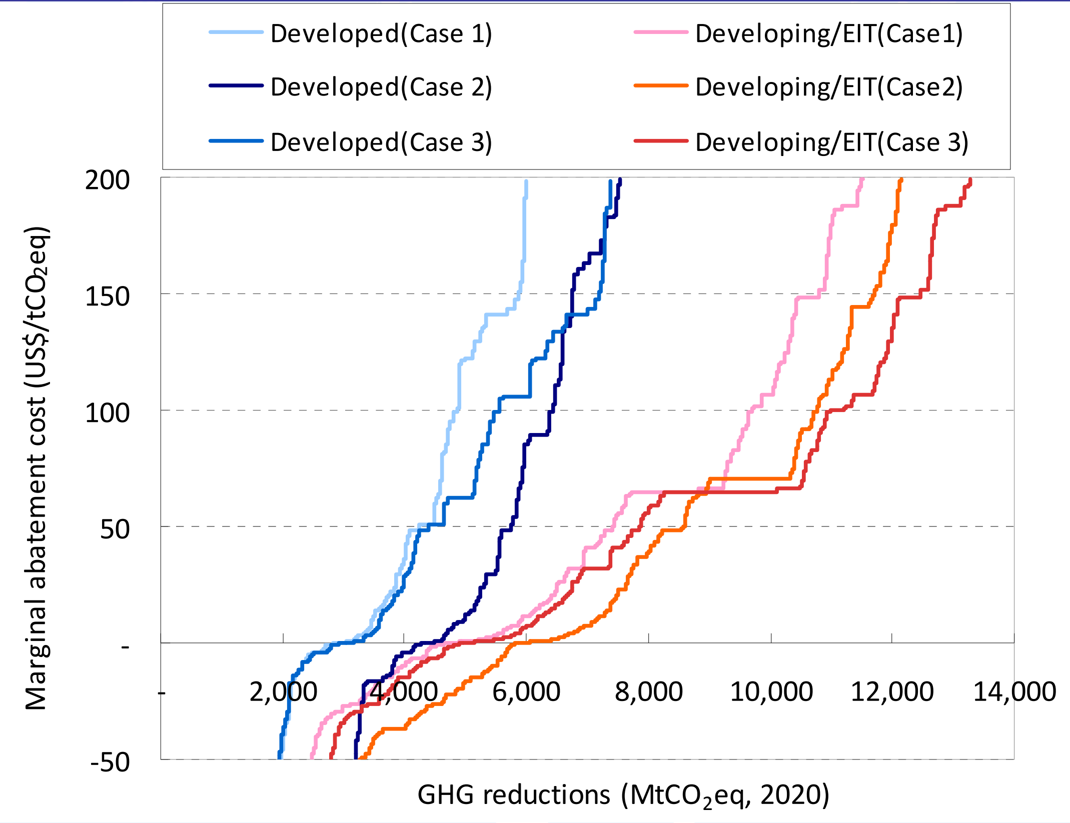
Payback period is one of the key factors which affect technology selection framework. Thus we compare reference (short payback period) and policy (long payback period) cases.

② Comparison of composition of power sources (Case 1 and Case 3)

Composition of power sources affects emission factors. Thus we compare composition of power sources with energy security restrictions and without restrictions (i.e. cost optimization)

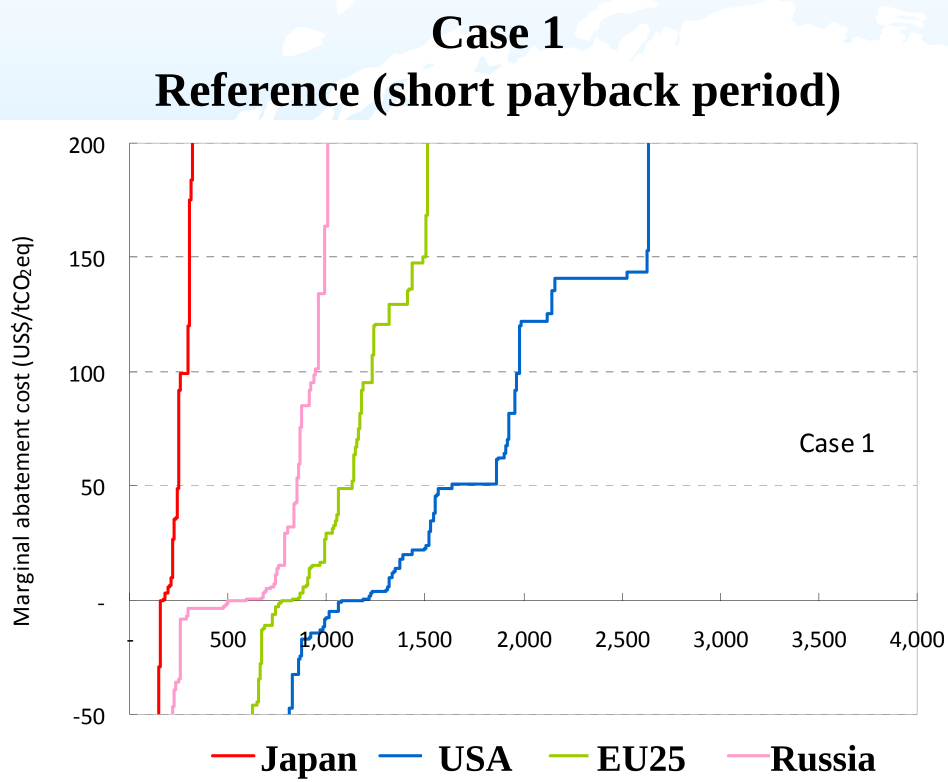


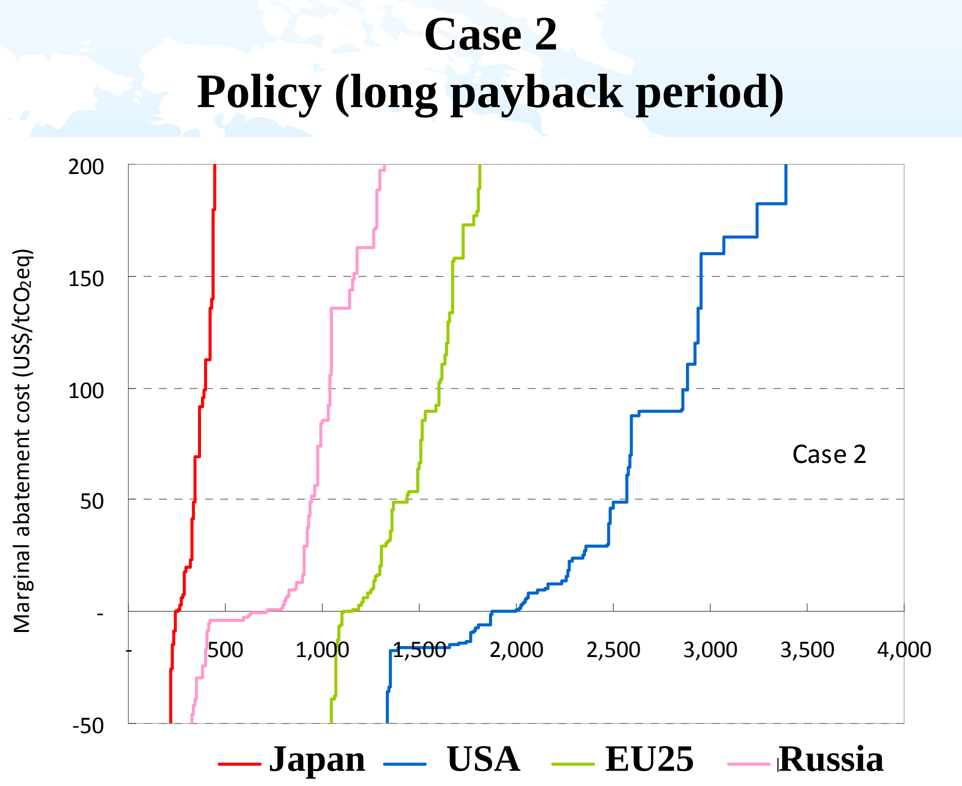
Marginal abatement cost curves in Developed and Developing countries in 2020



- There are larger mitigation potentials for cost-effective measures in developing / EIT countries. Thus international cooperation in technology transfers and financial assistance to developing countries may play an important role.
- Important point to note is that mitigation potentials and marginal abatement costs will vary depending on different data settings and assumptions as shown in Case 1 to Case 3.

Marginal abatement cost curves in 2020 in major developed countries in Case 1 & Case 2

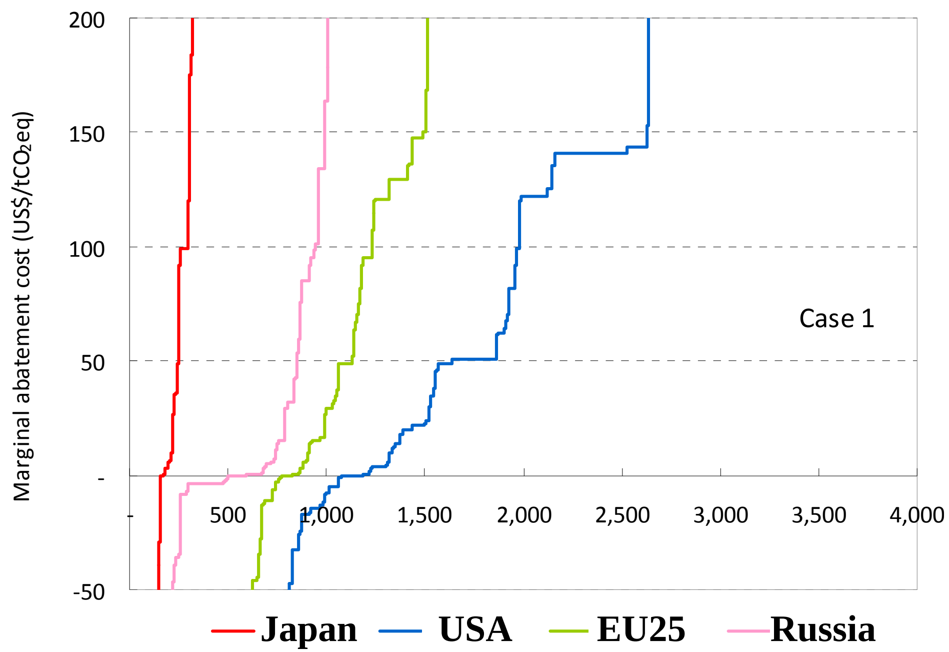




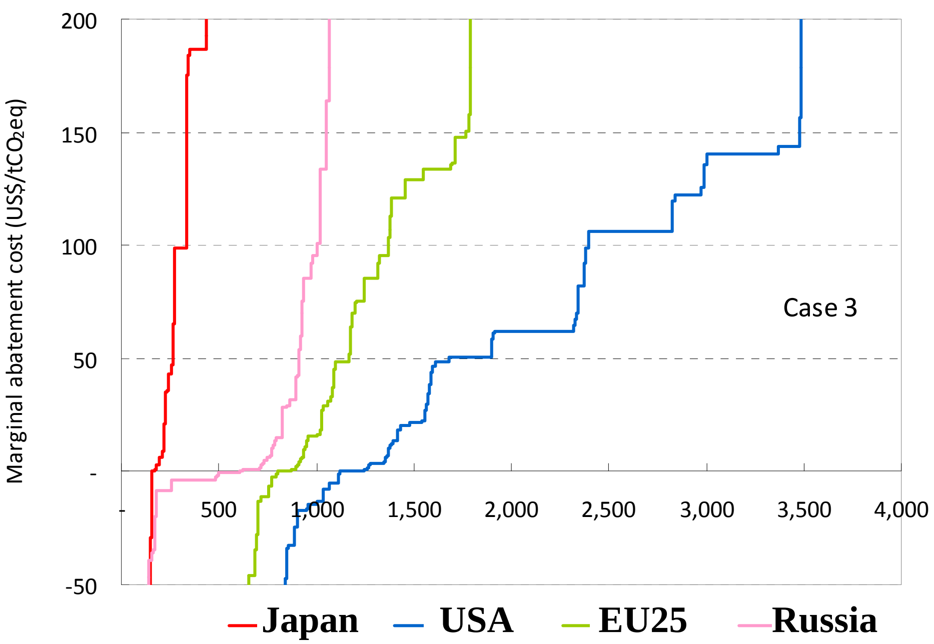
- **Reduction potentials in Japan are smallest among other major GHG emissions countries in developed regions.**
- **Comparing difference of payback period between Case 1 and Case 2, shape of MAC curves are quite similar but more mitigation potentials are estimated in Case 2 due to the effects of promoting high efficient technologies especially on the demand side.**

Marginal abatement cost curves in 2020 in major developed countries in Case 1 & Case 3

Case 1
Power sources with energy security restrictions

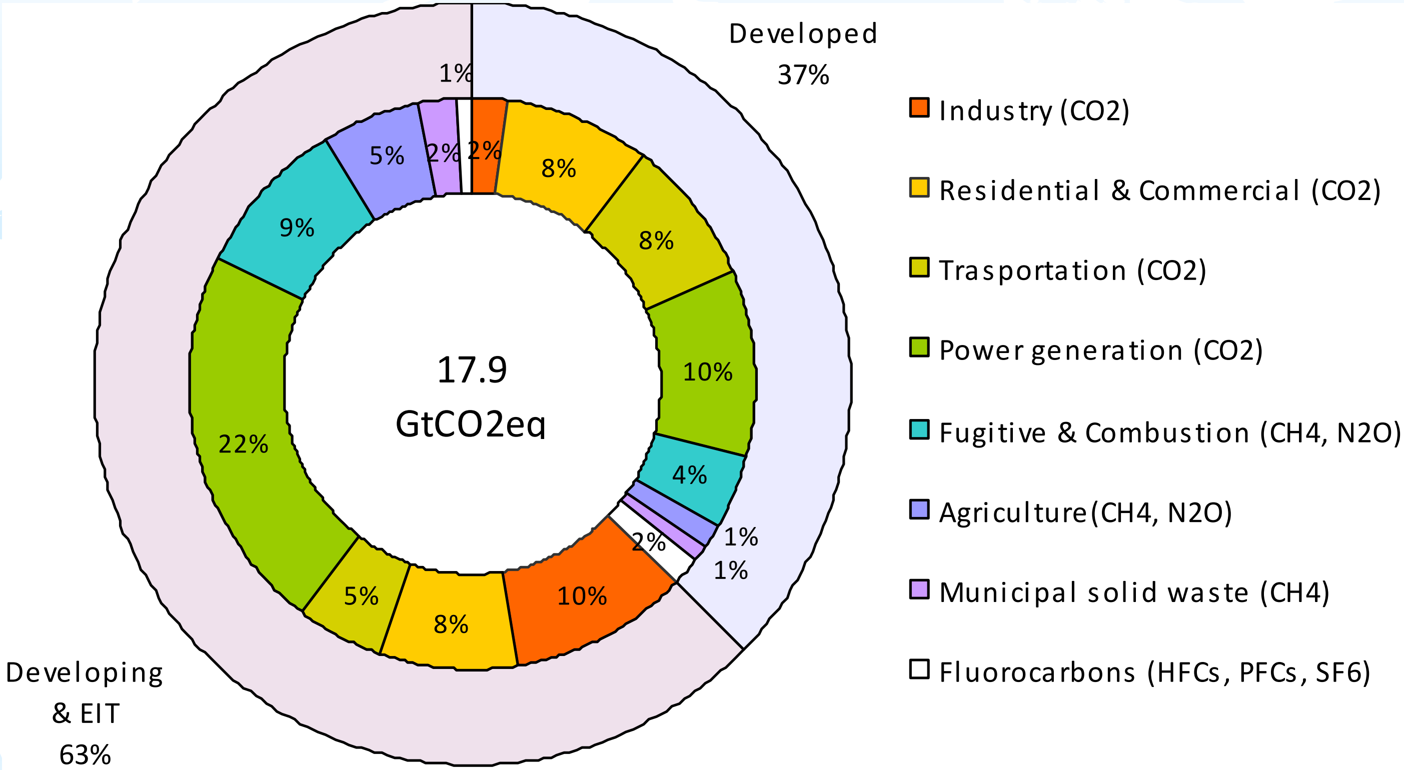


Case 3
Power sources without energy restrictions (cost optimization)



- **Comparing difference of composition of power sources between Case 1 and Case 3, shape of MAC curves are very similar when carbon price is low enough.**
- **However, more mitigation potentials are estimated in Case 3 above 50 US$/t-CO2 eq due to the effects of a drastic energy shift from existing coal and oil power plants to new efficient gas power plants.**

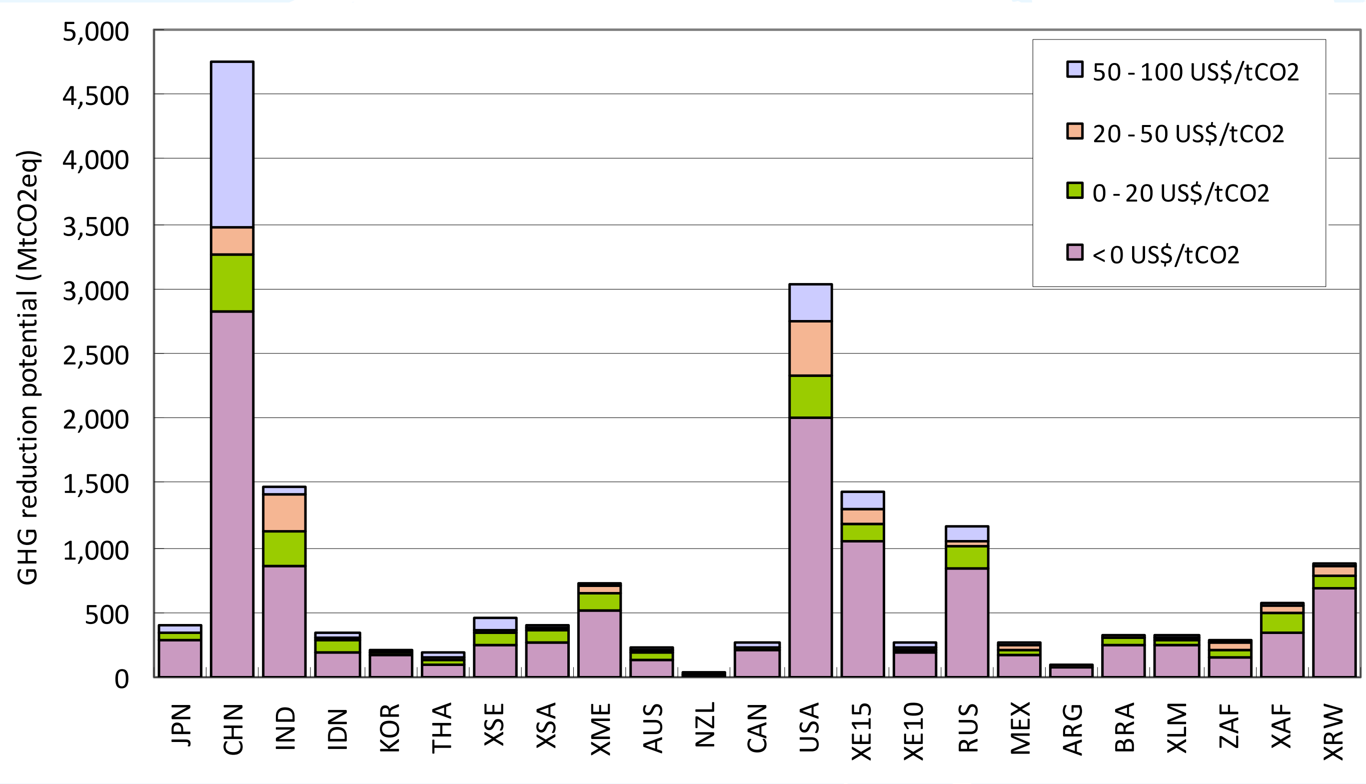
Ratio of sector-wise mitigation potentials in Developed and Developing in Case 2 in 2020



- **Large mitigation potentials are identified in the power generation and industry sectors due to the use of low energy-efficient technologies in developing and EIT countries. These sectors in developed and developing countries account for about 40~50% of the total potential.**
- **Mitigation potentials in developing countries account for about 60% of the total potential.**

Region-wise mitigation potentials in Case 2 in 2020 for different cost categories

Mitigation potentials from 0 to 100 US$/t$CO_2$ in Case 2



JPN	Japan
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XSA	Other South Asia
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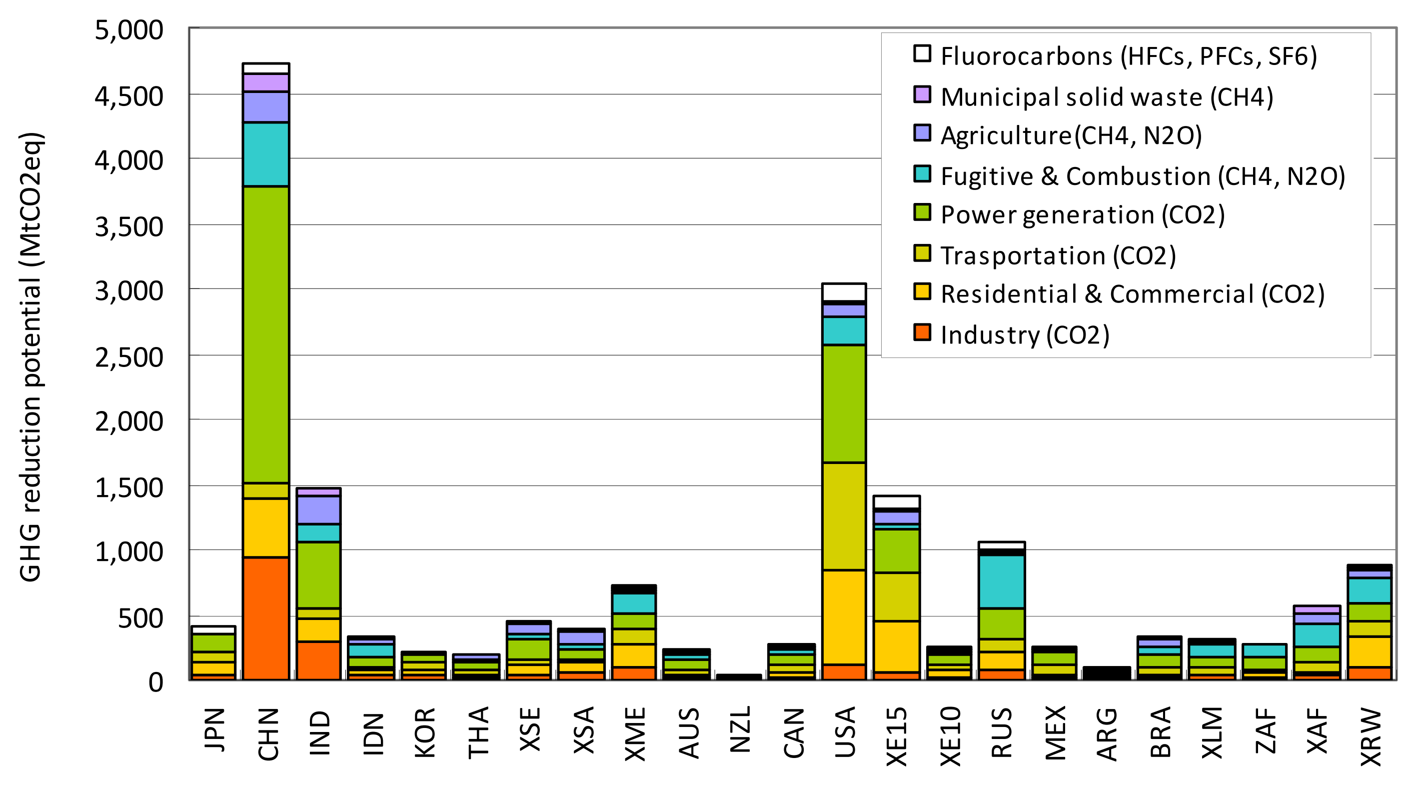
AUS	Australia
NZL	New Zealand
CAN	Canada
USA	USA
XE15	Western Europe(15)
XE10	Eastern Europe(10)
RUS	Russia
ARG	Argentine
BRZ	Brazil
MEX	Mexico
XLM	Other Latin America
ZAF	South Africa
XAF	Other Africa
XRW	Rest of the World

- China, US, India, Western Europe and Russia are five major regions with large reduction potentials, accounting for approximately 65~70% of the total reduction potential in the world.
- 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 Case 2 in 2020 under 100 US$/t-$CO_2$ for 23 regions

Mitigation potentials under 100 US$/t$CO_2$ in Case 2



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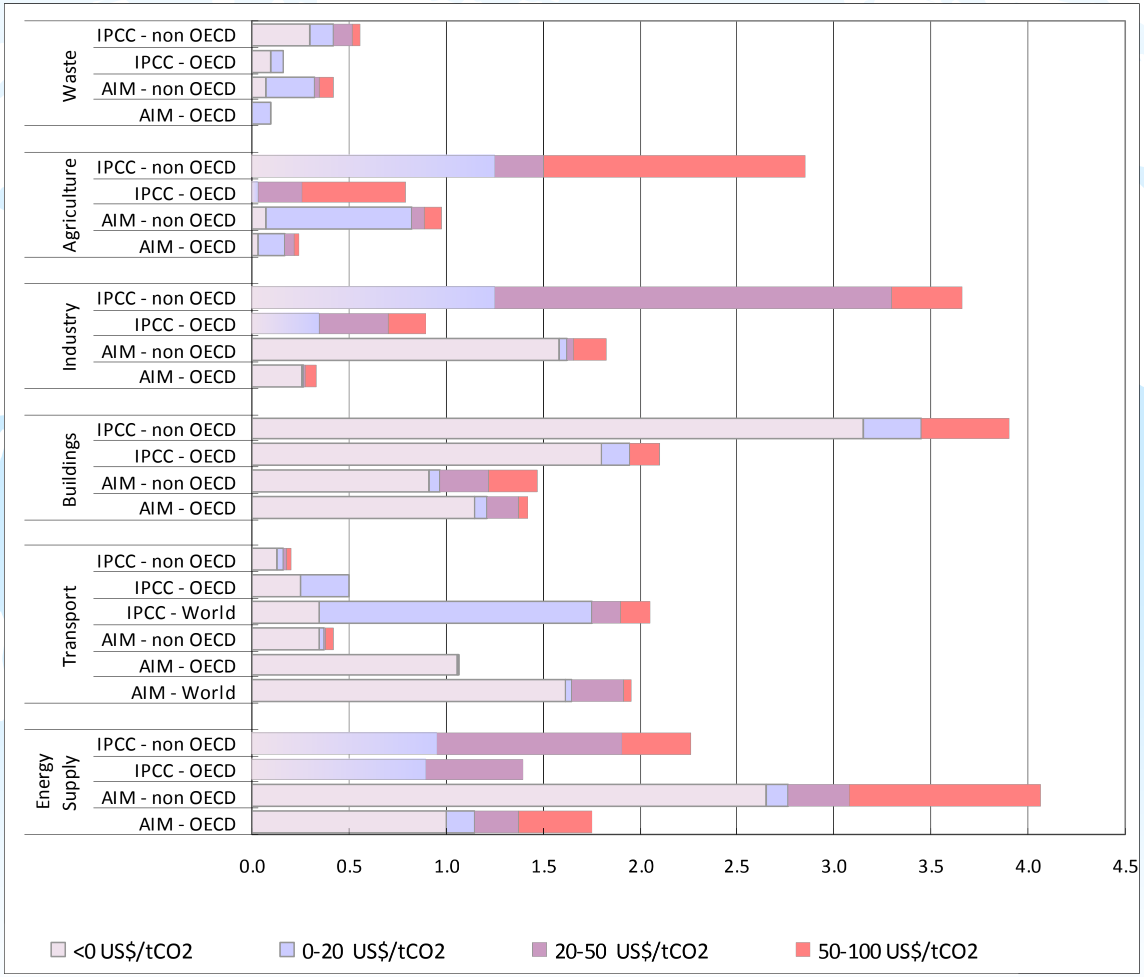
- **The major sectors which have large reduction potentials vary depending on the socio-economic characteristics of each region.**
- **For example, in China and India with high economic growth, reduction measures in industry and power generation sectors are significant. In developing countries, it is also effective to reduce emissions from agriculture and waste sectors.**

Comparison of this study in Case 2 with the IPCC AR4

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

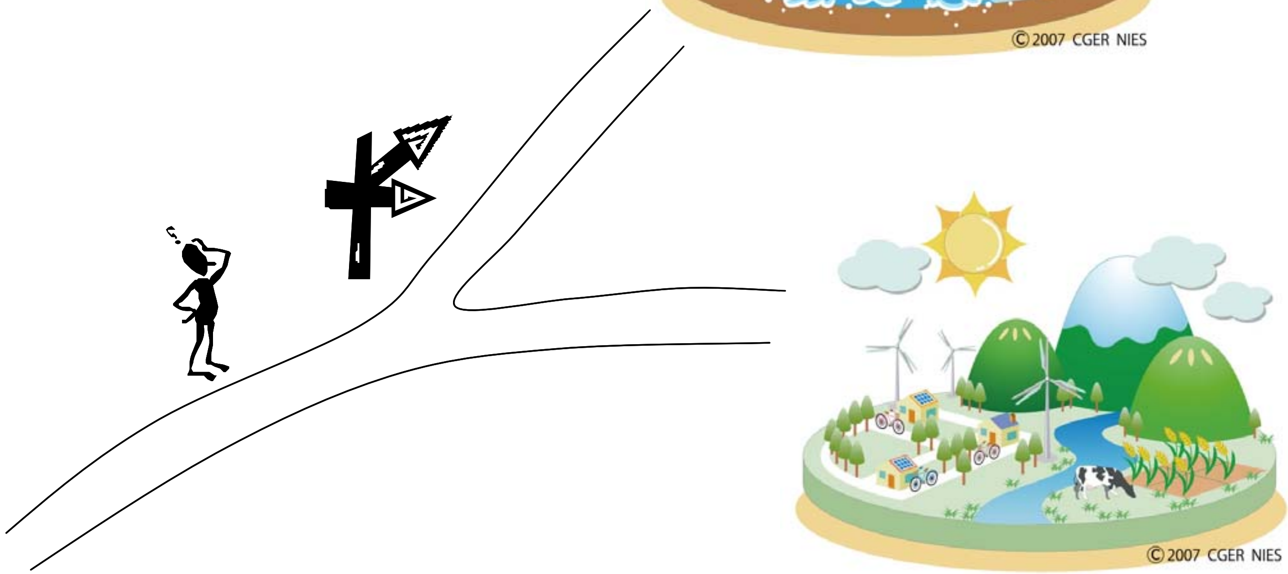


Note)

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

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.

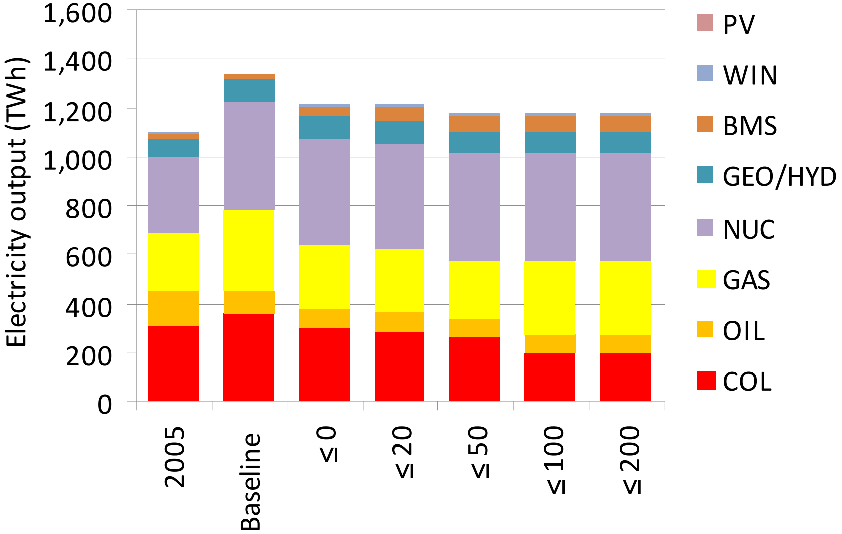
Timing is important!



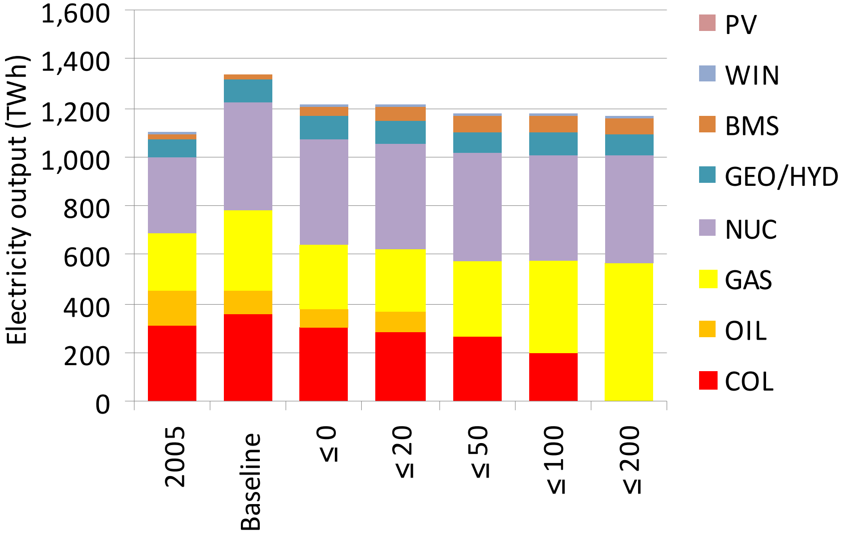
Thank you for your attention!

Appendix

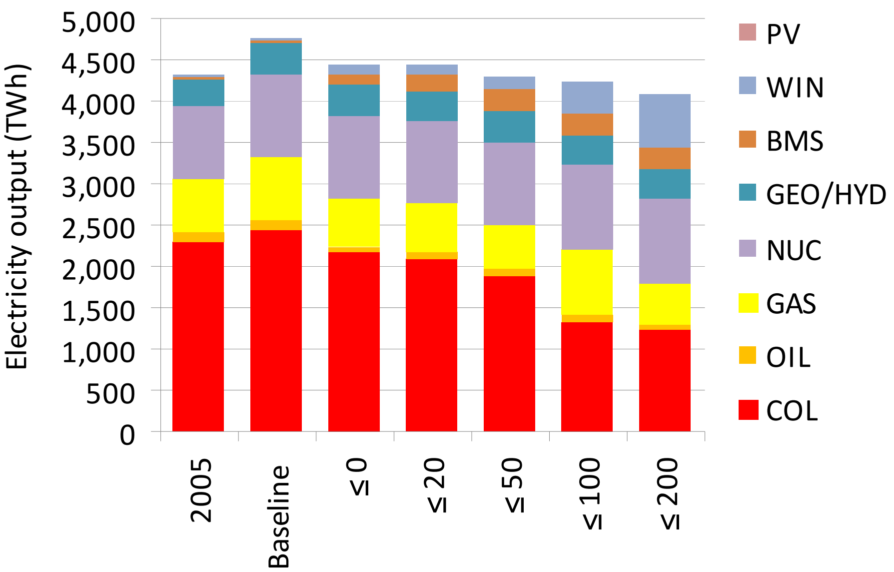
Composition of power sources



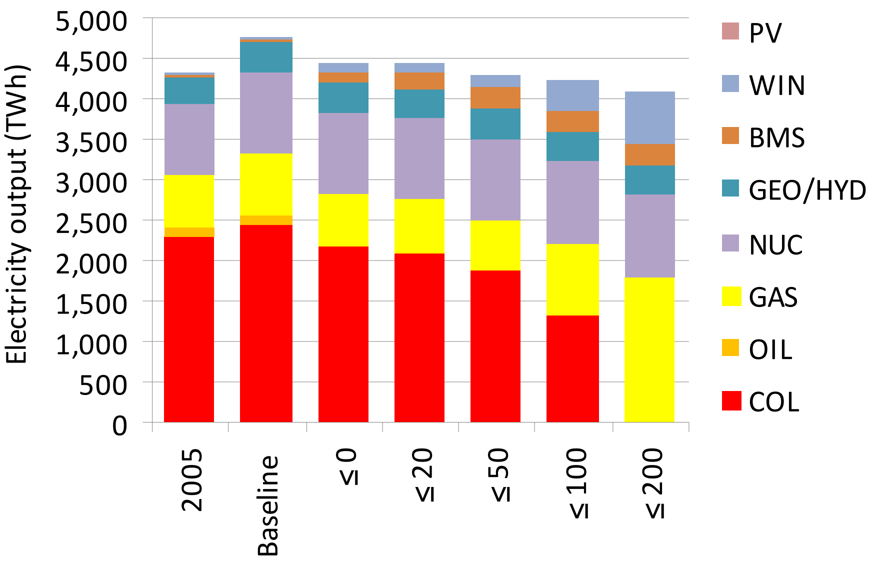
Japan in Case 1



Japan in Case 3

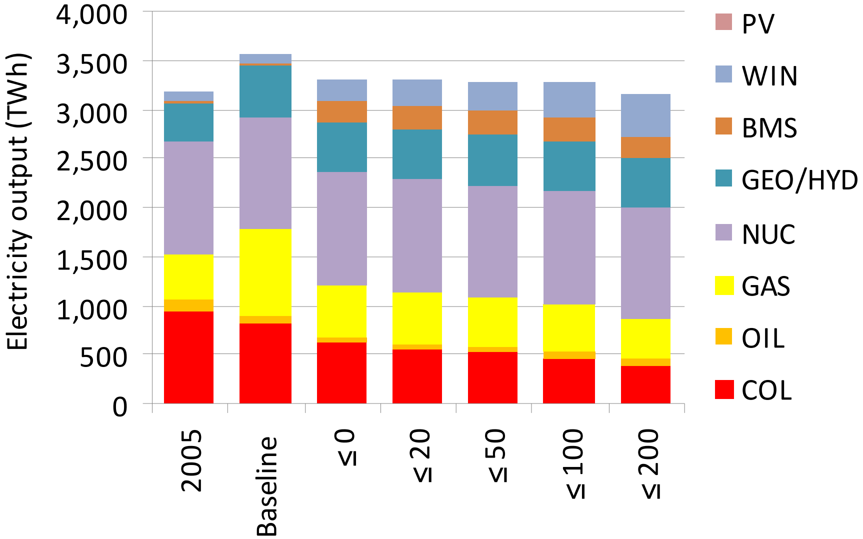


USA in Case 1

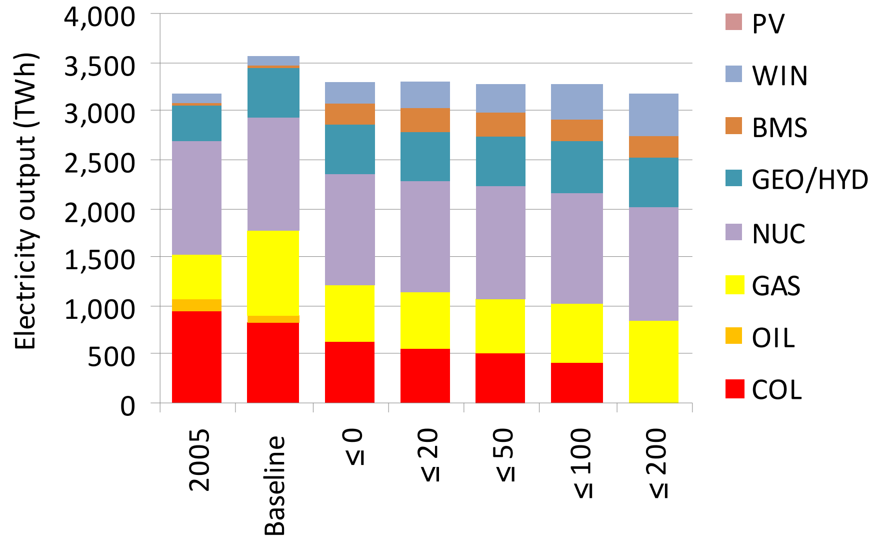


USA in Case 3

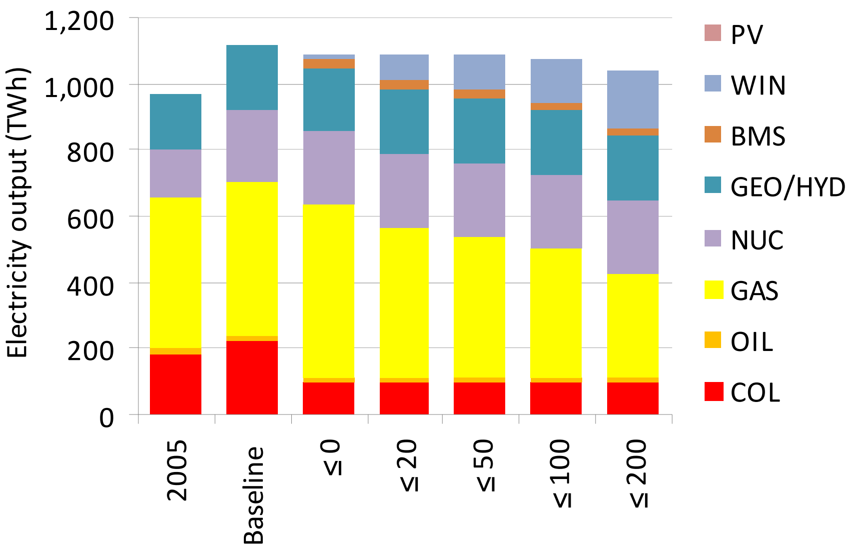
Composition of power sources



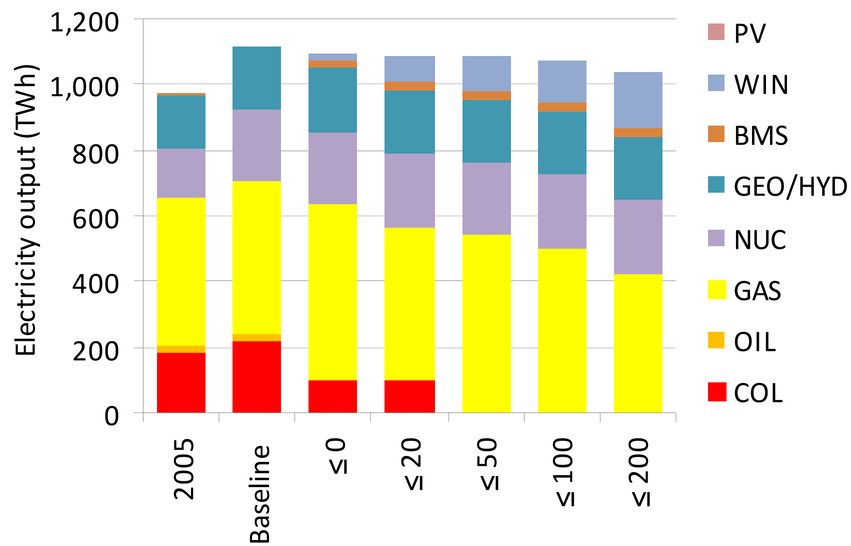
EU25 in Case 1



EU25 in Case 3



Russia in Case 1

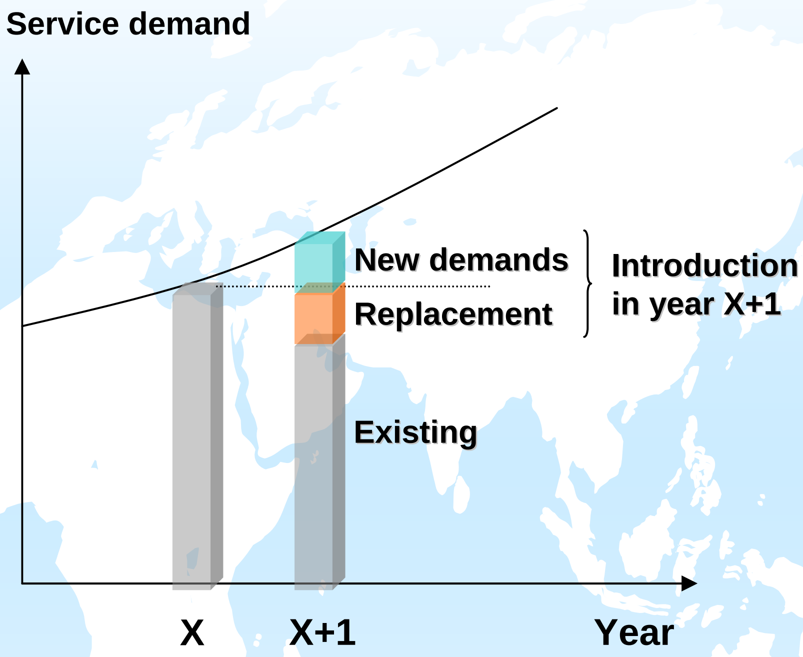


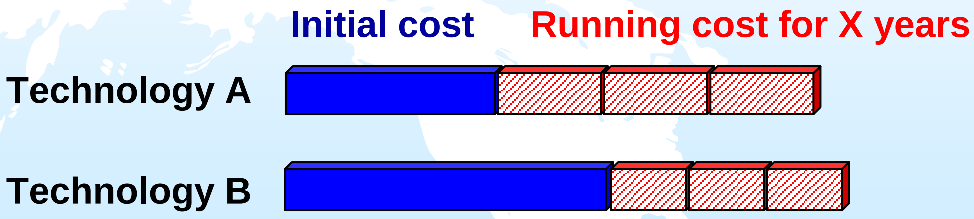
Russia in Case 3

Settings of payback period

Case	Sector	Setting of payback period	Example of payback period (Lifetime use in the model)
Case 1 Short payback	Industry, Residential, Commercial, Transport	For energy-related sectors such as industry, residential, commercial and transport, where a rate of technology improvement is high and there are technology perspectives on the temporal horizon, the payback period is assumed as around three years across these sectors. (i.e. the annual discount rate is set at 33% which corresponds to approximately three years payback period).	Residential equipments: 3 years (10-15years) Car, truck, bus: 3 years (8-12 years)
	Power plant Industry plant Infrastructure House insulation	The power generation sector which is considered as a kind of public industry, and facilities with long lifetimes, such as industrial plants, public transportation, and thermal insulation for homes and buildings, have longer payback periods to reduce investment risks. Therefore, the payback period is considered longer and assumed as around ten years. (i.e. the annual discount rate is set at 10 % which corresponds to approximately nine to ten years payback period under the assumption of 30 years lifetime for power plants).	Plant: 9-10 years (30 years) Train, ship, aircraft: 8-9 years (20 years) Insulation housing: 9-10 years (30years)
	Agriculture Waste Fluorocarbons	The features of the agriculture, waste, and fluorocarbon emission sectors are different from those of energy-related sectors. In these sectors, a rate of technology improvement is slow and there is less technology perspective in a short term, the payback period should be assumed longer enough to consider the lifetime of technology options. (i.e. in this study, it is set at a five % annual discount rate note 1)).	Agriculture: 1-11 year (1-15 year) MSW: 10-16 year (15-30 year) Fluorocarbons: 1-13 year (1-20year)
Case 2 Long payback	All sectors	Assuming shorter payback periods, only technologies with a low investment risk and a certain level of energy conservation are introduced. In order to promote more measures for energy conservation, policy measures should allow adequately long payback periods corresponding to about 50~70% of the technology's lifetime. (i.e. a 5% annual discount rate was considered across all sectors and all regions).	Residential equipments: 7-10 years (10-15years) Car, truck, bus: 6-9 years (8-12 years) Plant: 14-15 years (30 years) Insulation housing: 15-16 years (30years)

Logic of technology selection





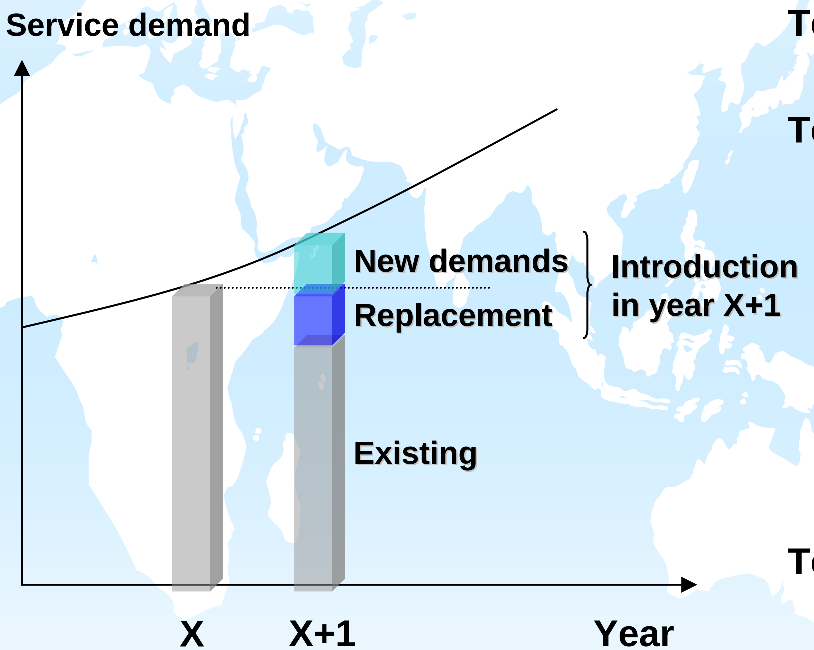
If Tech A < Tech B ⇒ then Tech A is selected

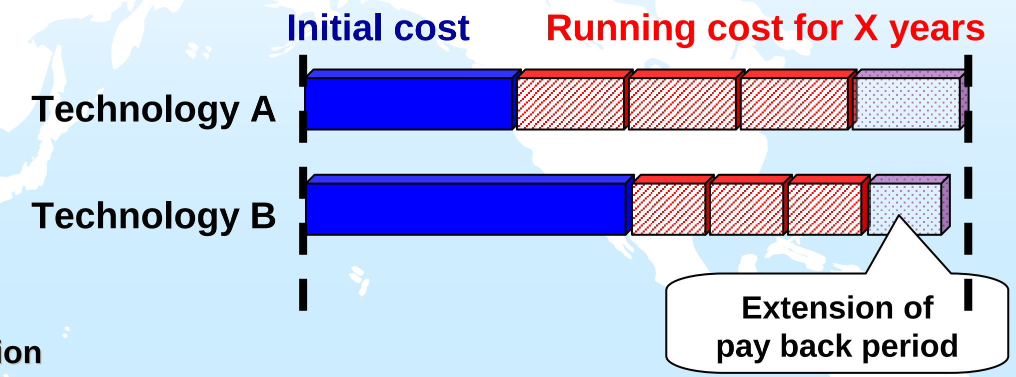
As private industries take into account high investment risk for energy conserving technologies, **a payback period of 3-years** is assumed.

e.g.) The specific discount rates for investments corresponding to 3-years payback is about 33% based on the assumption of 30 years lifetime for steel plants.

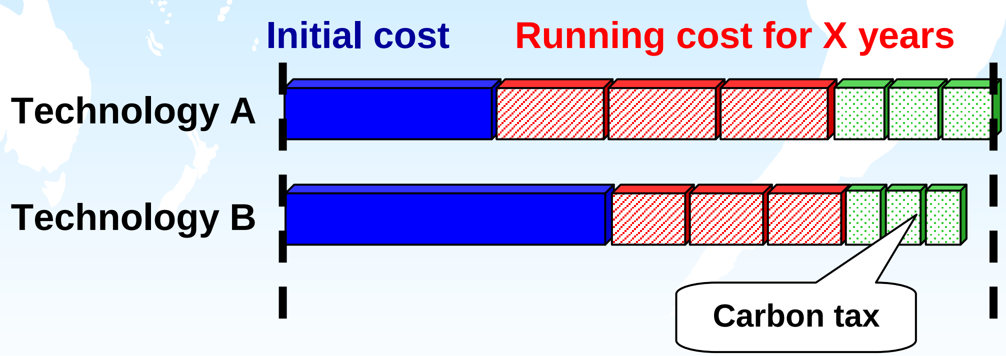
Logic of technology selection

(1) Replacement, new demands





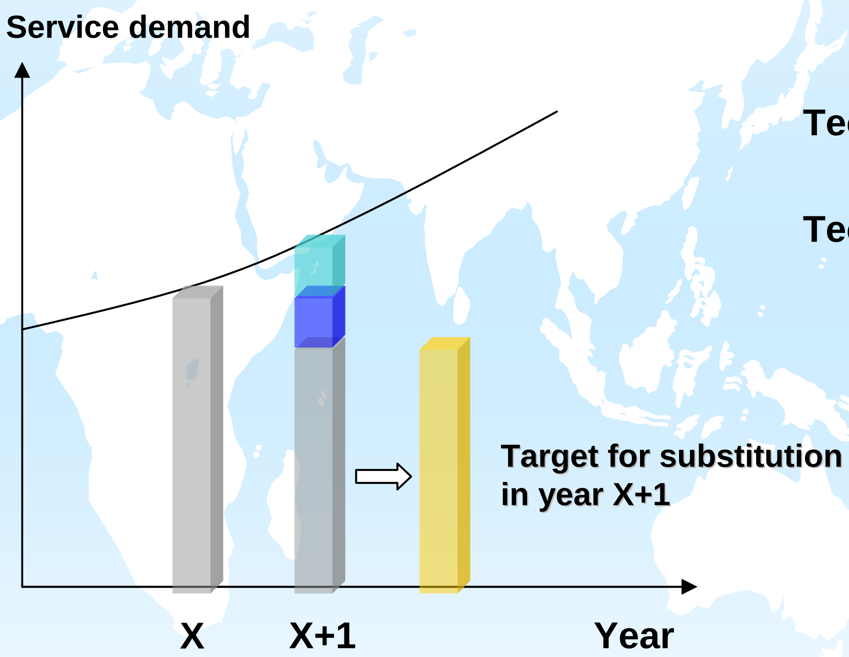
If Tech A < Tech B ⇒ then Tech B is selected

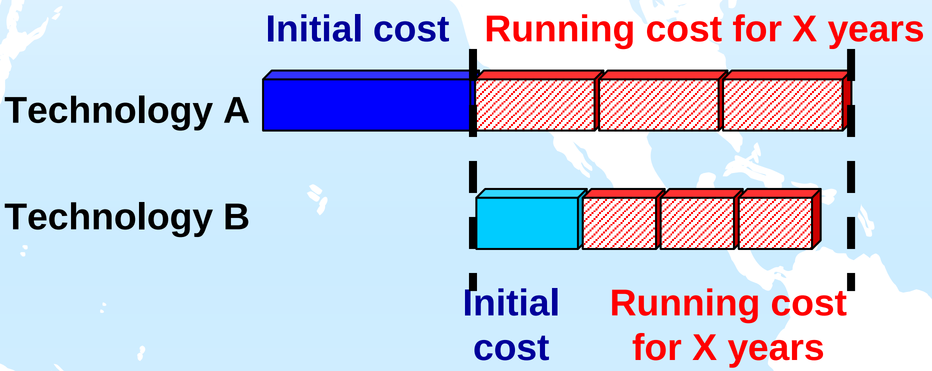


If Tech A < Tech B ⇒ then Tech B is selected

Logic of technology selection

(2) Substitution of existing technology





If Tech A < Tech B ⇒ then <u>Tech B</u> is selected