International Meeting on Land Use and Emissions in South/Southeast Asia
Ho Chi Mihn City, Vietnam
17-19 October 2016

LLGHG (Long-Lived GHGs), SLPCs (Short-Lived Climate Pollutants), Air Pollutants Emissions Projections and Ructions in Asia and the World

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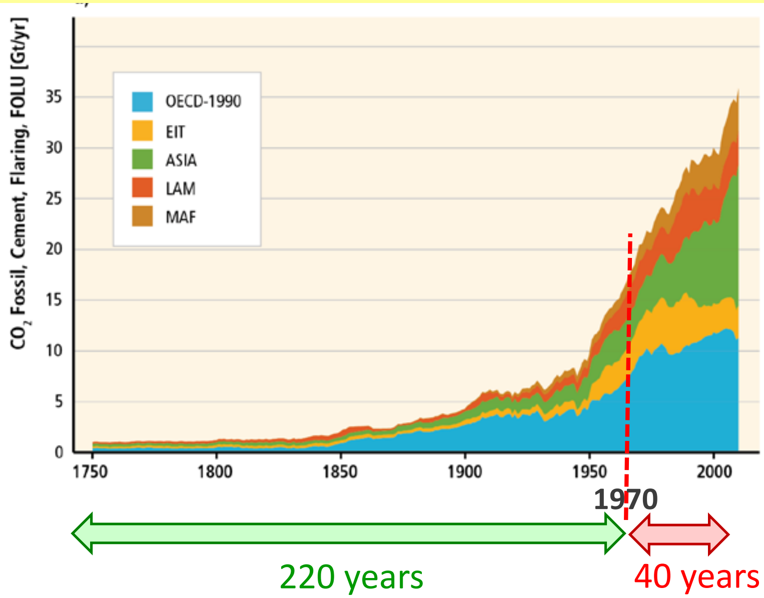
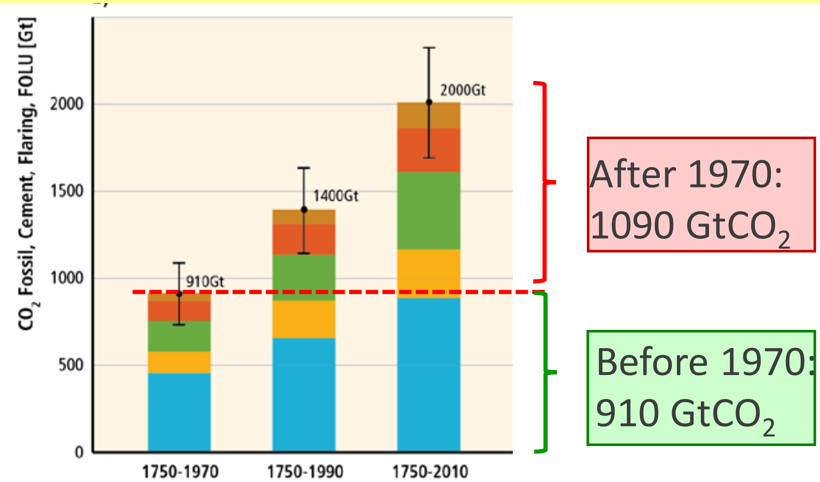
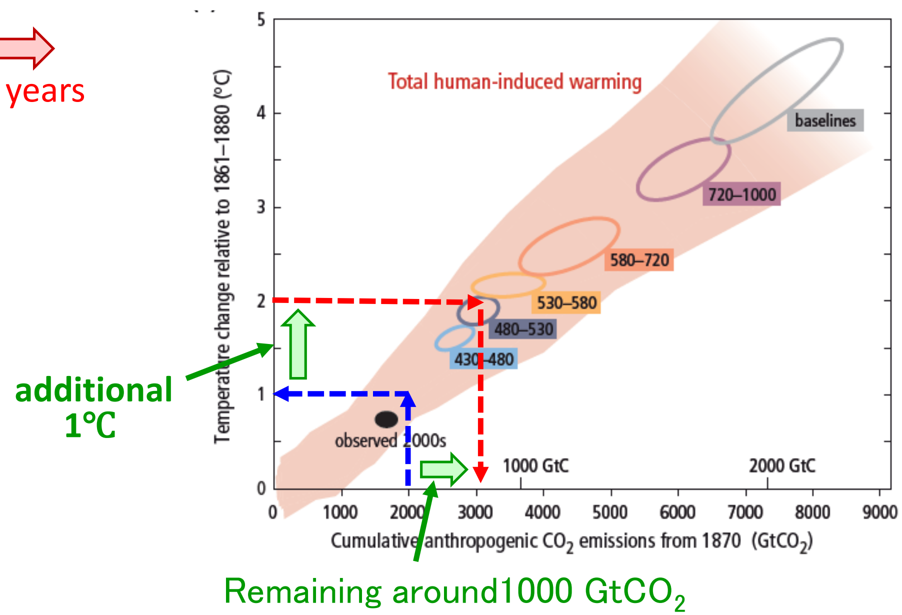
Implication of the 2 ℃ increase relative to pre-industrial levels
- why important to think of cumulative emissions? -

- Anthropogenic cumulative CO_2 emissions have more than doubled from 1750-1970 to 1970-2010
- **Remaining cumulative CO_2 emissions (i.e. carbon budgets) staying below 2℃ are around 1000 $GtCO_2$**





Note)
OECD-1990: OECD countries affiliated in 1990
EIT: Economies in Transition
ASIA: Asian countries
LAM: Latin America countries
MAF: Middle East and Africa countries



Source)
IPCC AR5 WG3 Technical Summary (2015), Figure TS.2
IPCC AR5 Synthesis Report (2015) Figure SPM.5

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(Intended) Nationally Determined Contributions
- example of submitted data -

Cautions: 1) Base year and target year are not unique among countries.
2) Target characteristics (i.e. intensity target, emission target etc) are not unique amongcountries.

Country	Base year	Target year	Overview of targets
EU	1990	2030	• At least, 40% GHG reduction by 2030 compare to the 1990 level
USA	2005	2025	• 26 – 28 % GHG reduction compare by 2025 to the 2005 level
Russia	1990	2030	• 25 – 30 % GHG reduction by 2030 compare to the 1990 level
China	2005	2030	• 60 – 65% reduction by 2030 in the unit of CO2 emission per GDP compared to the 2005 level. • Peaking CO2 emissions around 2030 and making best efforts to peak early • Non-fossil fuels share in primary energy consumption to around 20% by 2030
India	2005	2030	• 33 – 35% reduction by 2030 in the unit of GHG emission per GDP compared to the 2005 level. • Non-fossil fuels share in electric power capacity to around 40% by 2030
Brazil	2005	2025	• 37% GHG reduction by 2025 compared to the 2005 level (subsequent contribution: 43% GHG reduction by 2030 compared to the 2005 level)
Mexico	2005	2030	• 22% GHG reduction and 51% BC reduction by 2030 compared to the 2005 level • In a conditional manner, 36% GHG reduction and 70% BC reduction by 2030 compared to the 2005 level
Indonesia	BaU	2030	• 26% and 29% GHG reduction by 2020 and 2030, respectively, compared to the BaU emission level • In a conditional manner, 41% GHG reduction by
Korea	BaU	2030	• 37% GHG reduction by 2030 compared to the BaU emission level
Japan	2013	2030	• 26% GHG reduction by 2030 compared to the 2013 fiscal year level (i.e. 25.4% GHG reduction compared to the 2005 fiscal year level)

See in detail about INDC database at WRI web: http://cait.wri.org/
and at Climate Nexus web: http://www.theroadthroughparis.org/negotiation-issues/indcs-submitted-date-0

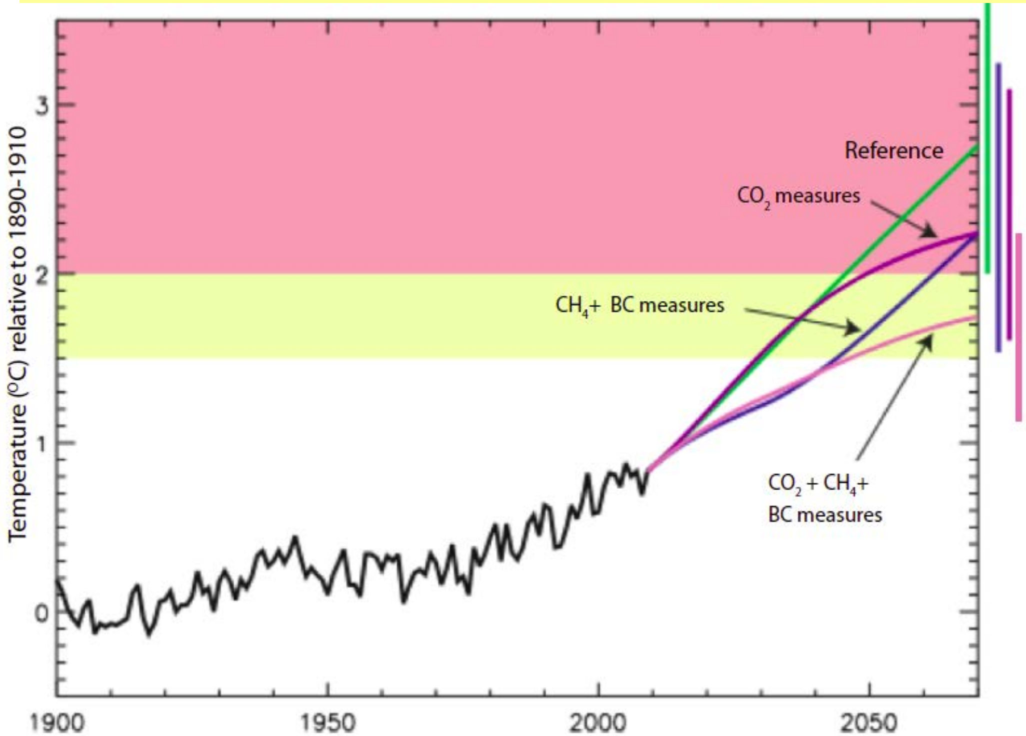
Summary of scientific findings about emission gaps among NDCs and the pathways staying below 2℃

- **INDCs are insufficient and not in line with pathways to stay below 2℃, but INDCs are an starting point** to move the world toward the 2℃ emissions pathways.
- Even if INDCs are fully implemented, **the required rate of mitigation measures are stringent and rapid after 2030**, in order to achieve the 2℃ pathways.

Institute	Aggregated global GHG emission levels, based on pledged targets	Remaining gaps with emissions pathways staying below 2℃	Temperature increase above pre-industrial level, based on pledged targets
IPCC (2014)	52–56 Gt CO2eq in 2020 (Note: Cancun pledges)	8–12 Gt CO2eq in 2020	correspond to staying below 3 ℃ target
UNFCCC (2015)	52.0-56.9 Gt CO2eq in 2025 53.1-58.6 Gt CO2eq in 2030	4.7-13.0 Gt CO2eq in 2025 11.1-21.7 Gt CO2eq in 2030	2.7℃ of waring by 2100
UNEP (2015)	53-54 Gt CO2eq in 2025 54-56 Gt CO2eq in 2030	5– 7 Gt CO2eq in 2025 12–14 Gt CO2eq in 2030	<3.0–3.5℃ of waring by 2100
PBL (2015)		12–14 Gt CO2eq in 2030	
IDDRI (2015)	54 Gt CO2eq in 2030		
Climate Action Tracker (2015)	51.6–54.1 Gt CO2eq in 2025 52.3–55.1 Gt CO2eq in 2030	17 Gt CO2eq in 2030	2.7℃ (range of 2.2–3.4℃) of waring by 2100
Climate initiative (2015)			3.2–3.5℃ of waring by 2100
NIES (2015)	51.8 Gt CO2eq in 2030	13 Gt CO2eq in 2030	3.3℃ of waring by 2100

UNEP/WMO SLCP report (2011)
- Reducing of SLCP emissions & Inhibiting Temperature Rise -

- Reducing SLCPs (CH_4, BC, tropospheric O_3) offers a realistic opportunity to significantly reduce the rate of global warming over the next two to four decades.
- If fully implemented by 2030, it reduces global warming between 2010 to 2040 by about 0.4 – 0.5 °C



CO2 reduction only

CO2 & SLCP reduction

How about air pollutants reductions and their benefits and trade-offs?

Is it still true, based on the latest models and the latest data sets?

What kinds of SLCP measures? How drastic it should be?

Source）
Figure6.1, UNEP/WMO (2011) Integrated Assessment of BC and tropospheric O3
Figure ES-2, UNEP (2011) Near-term Climate Protection and Clean Air Benefits: Actions for Controlling Short-Lived Climate Forcers

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MOEJ-S12: Promotion of climate policies by assessing environmental impacts of SLCP and seeking LLGHG emission pathways (FY2014 – FY2018)

Goal: To develop an integrated evaluation system for LLGHG and SLCP mitigation policy, by interconnecting emission inventory, integrated assessment models, and climate models.

Theme 1: Air quality change event analysis
- Analysis on regional AQ change
- Development of emission inventory
- Inversion algorithms of emission estimation

Theme 2: Integrated model and future scenarios
- Global socio-economic scenarios
- National & regional emissions scenarios
- Urban & household emissions AQ assessment

Theme 3: SLCP impacts on climate & environment
- Impact assessment of aerosols & GHG
- Assessment of health, agriculture, water cycle, sea level rise

Improved emission inventory

SLCP emissions scenarios

Regional Emission Inventories and Chemical Transfer Model

Integrated Assessment Model (AIM)

Climate and Environment Model

Assessment of activities/policies

Feedback of impacts

Chemical transfer model and emission inventory in Asia

AIM/Enduse model
Socio-economical & emissions scenario

Climate model, earth system model
Climate change impact & adaptation

Theme 4: Integrated operation system (Toolkits, data archive)

Science

Stakeholders
Policy makers

Society

Model improvement

System utilization

Information transmission

Experiment setup
Database development
Metric definitions

CCAC, UNFCCC, IPCC, EANET
Proposal and assessment of climate and air pollution policies

MDG・SDG・Future Earth

Regional strategy ⇅ Global strategy

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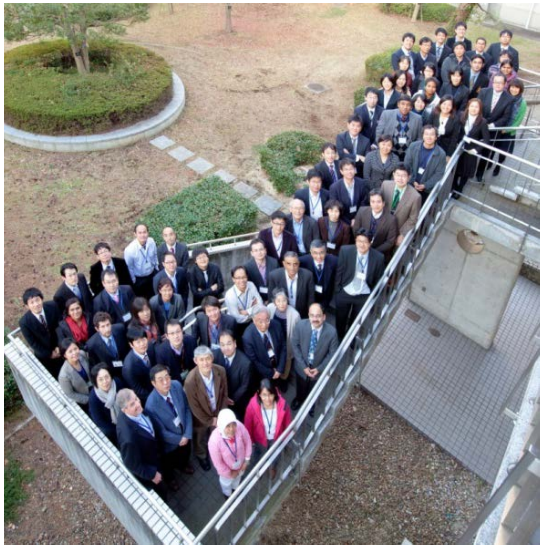
Challenges of S-12 Theme 2

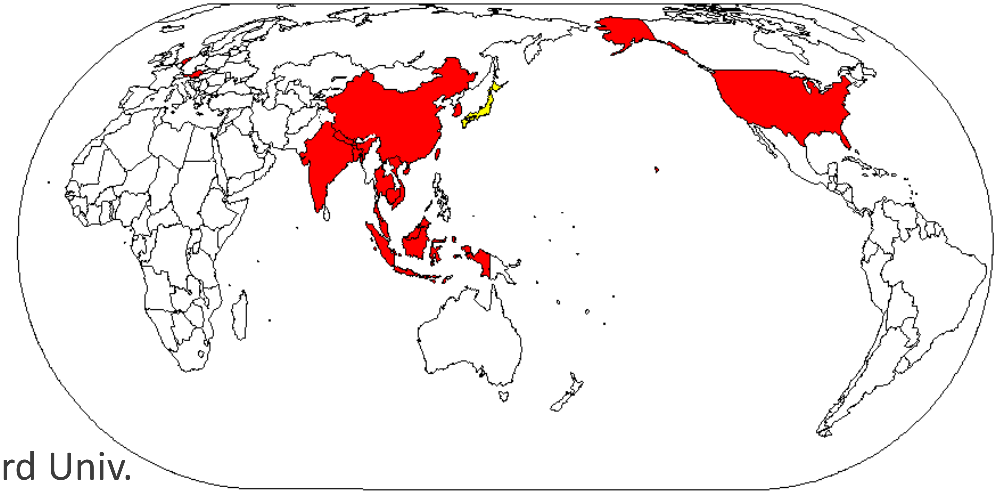
1. Estimating **future (energy & non-energy) service demands based on new socio-economic scenarios** (i.e. SSPs: Shared-Socioecnomic Pathways) considering climate change and environmental impacts
2. indicating **emissions scenarios of Long-lived GHGs(LLGHG) and Short lived Climate Pollutants (SLCP) and air pollutants,** based on new service demands estimations
3. Evaluating **co-benefits of LLGHG mitigation measures and SLCP reduction measures**, and analyzing regional characteristics in detail, **in a manner consistent with long-term global scenarios** such as 2°C target.
4. Exploring the **appropriate balance among LLGHGs measures, SLCPs measures and air pollutants measures** from the viewpoint of health benefits and climate benefits.

Today's Topic

AIM (Asia-pacific Integrated Model)
- International Research Network -



Japan	National Institute for Environmental Studies Kyoto University Mizuho Information Research Institute
China	Energy Research Institute, NDRC Institute of Geog. Sci. & Nat. Res. Research, CAS Institute of Env. & Sus. Dev. in Agri, CAAS Guangzhou Institute of Ene. Conversion, CAS
India	Indian Institute of Management, Ahmedabad School of Planning and Architecture, Bhopal
Korea	Seoul National Univ. Korea Environment Institute
Thailand	Asian Institute of Tech. Thammasat Univ. King Mongkut's Univ.
Malaysia	Univ. Tech. Malaysia
Indonesia	Bogor Agri. Univ. Bandung Institute of Tech.
Austria	IIASA
Netherlands	PBL
USA	Pacific Northwest National Lab. Energy Modeling Forum, Stanford Univ.



In addition, collaborating with **Vietnam, Cambodia, Bangladesh, Nepal, Taiwan**, ...

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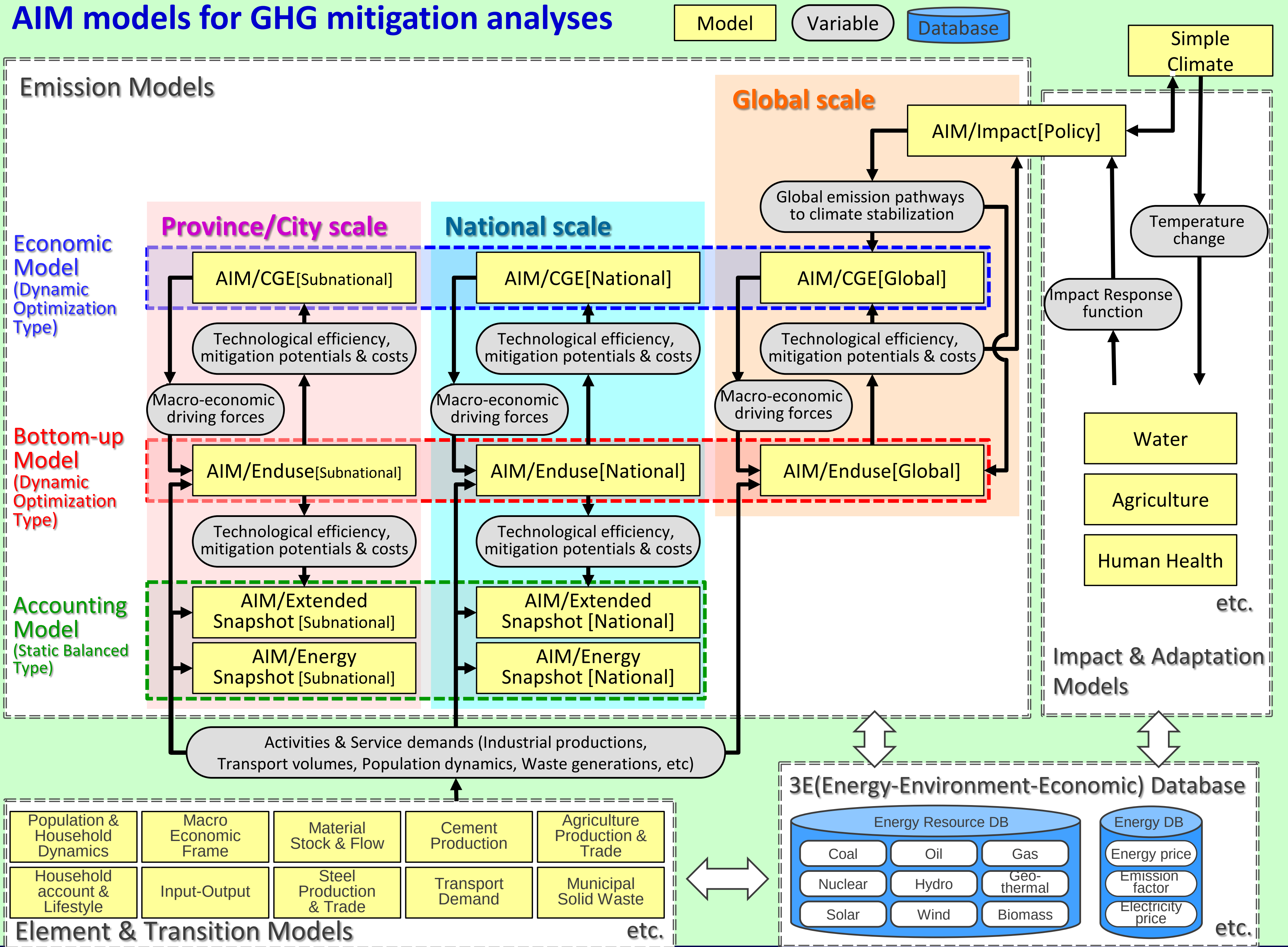
AIM models for GHG mitigation analyses



Characteristics of AIM/Enduse model

- Bottom-up type model with detailed technology selection framework with optimizing the total system cost
- Recursive dynamic model (=Calculating year by year)
- Assessing technological transition over time
- Analyzing effect of policies such as carbon/energy tax, subsidy, regulation and so on.
- Target Gas: both Long-Lived GHGs and Short-Lived Climate Pollutants CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, CFCs, HCFCs, SO_2, NOx, BC, etc
- Target Sectors : multiple sectors

  power generation sector, industry sector, residential sector, commercial sector, transport sector, agriculture sector, municipal solid waste sector, fugitive emissions sector, F-gas sector

  (each of these can be further disaggregated into sub-sectors)

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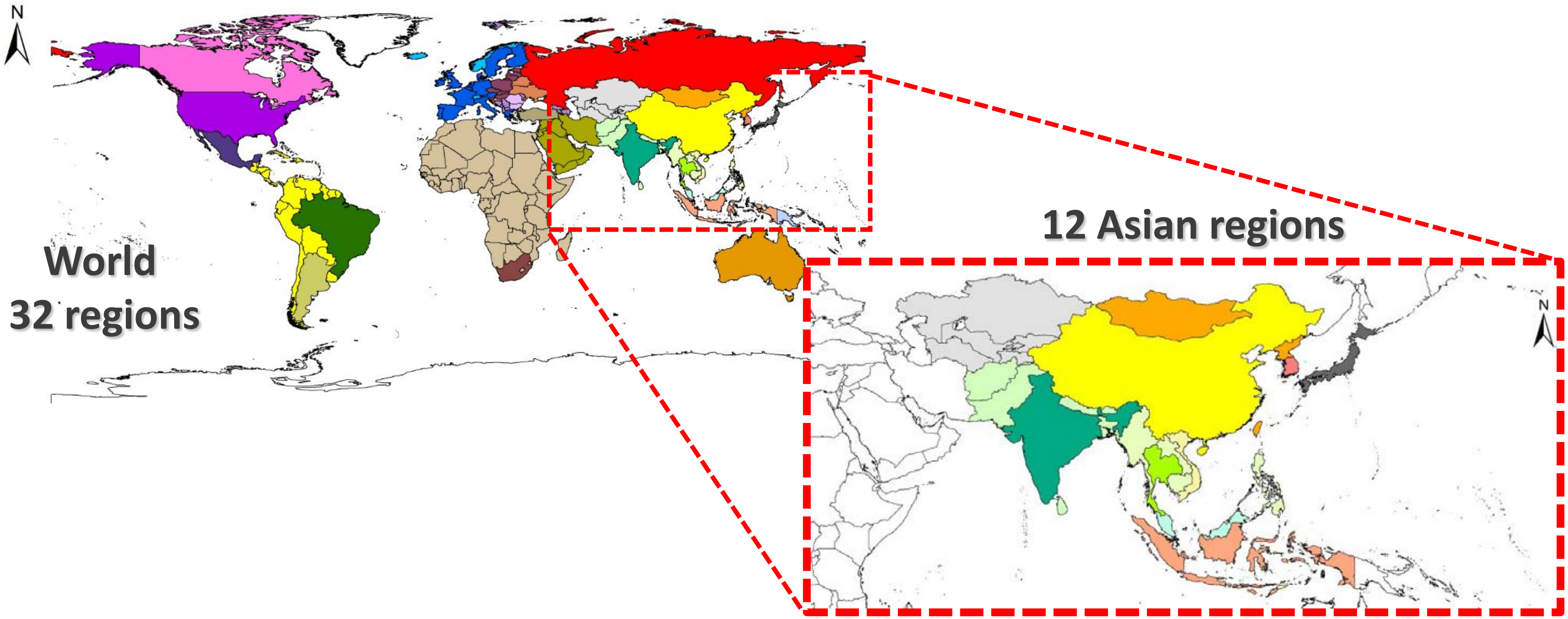
AIM/Enduse[Global] model - Regional Classification -



Annex I

OECD

JPN(Japan)	USA(USA)	CAN(Canada)	KOR(Korea)
AUS(Australia)	XE15(EU-15 in Western Europe)	TUR(Turkey)	MEX(Mexico)
NZL(New Zealand)	XE10(EU-10 in Eastern Europe)	XEWI(Other Western Europe in Annex I)	BRA(Brazil)
RUS(Russia)	XE2(EU-2 in Eastern Europe)	XEEI(Other Eastern Europe in Annex I)	ARG(Argentine)
CHN(China)	XSA(Other South Asia)	XENI(Other Europe)	XLM(Other Latin America)
IND(India)	XEA(Other East Asia)	XCS(Central Asia)	ZAF(South Africa)
IDN(Indonesia)	XSE(Other South-east Asia)	XOC(Other oceania)	XAF(Other Africa)
THA(Thailand)	MYS(Malaysia)	VNM(Viet Nam)	XME(Middle East)

ASEAN

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AIM/Enduse[Global] model - Target Gases and Sectors

Mitigation options listed in the following sectors are considered in the AIM/Enduse[Global] model

Sector	Sub sectors whose mitigation actions are considered in Enduse model (other subsectors are treated as scenario)
Power generation	Coal power plant, Oil power plant, Gas power plant, Renewable (Wind, Biomass, PV), Nuclear, Hydro, Geothermal, Heat
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, Other equipments
Agriculture	Livestock rumination, Manure management, Paddy field, Cropland
MSW	Municipal solid waste, Waste water management
Fugitive	Fugitive emission from fuel production
Fgas emissions	By-product of HCFC-22, Refrigerant, Aerosol, Foams, Solvent, Etching, Aluminum production, Insulation gas, others.

	CO2	CH4	N2O	HFCs	PFCs	SF6	CFCs	HCFCs	SO2	NOx	BC	OC	PM10	PM2.5	CO	NH3	NMVOC	Hg
Fuel combustion	✔	✔	✔						✔	✔	✔	✔	✔	✔	✔	✔	✔	
Industrial process	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	
Agriculture		✔	✔													✔		
Waste		✔																
Fuel mining		✔																
Others	✔	✔	✔													✔	✔	

Note) Emission factors can be set by energy, by sector and by region over time.
Settings on technology options are the same, too

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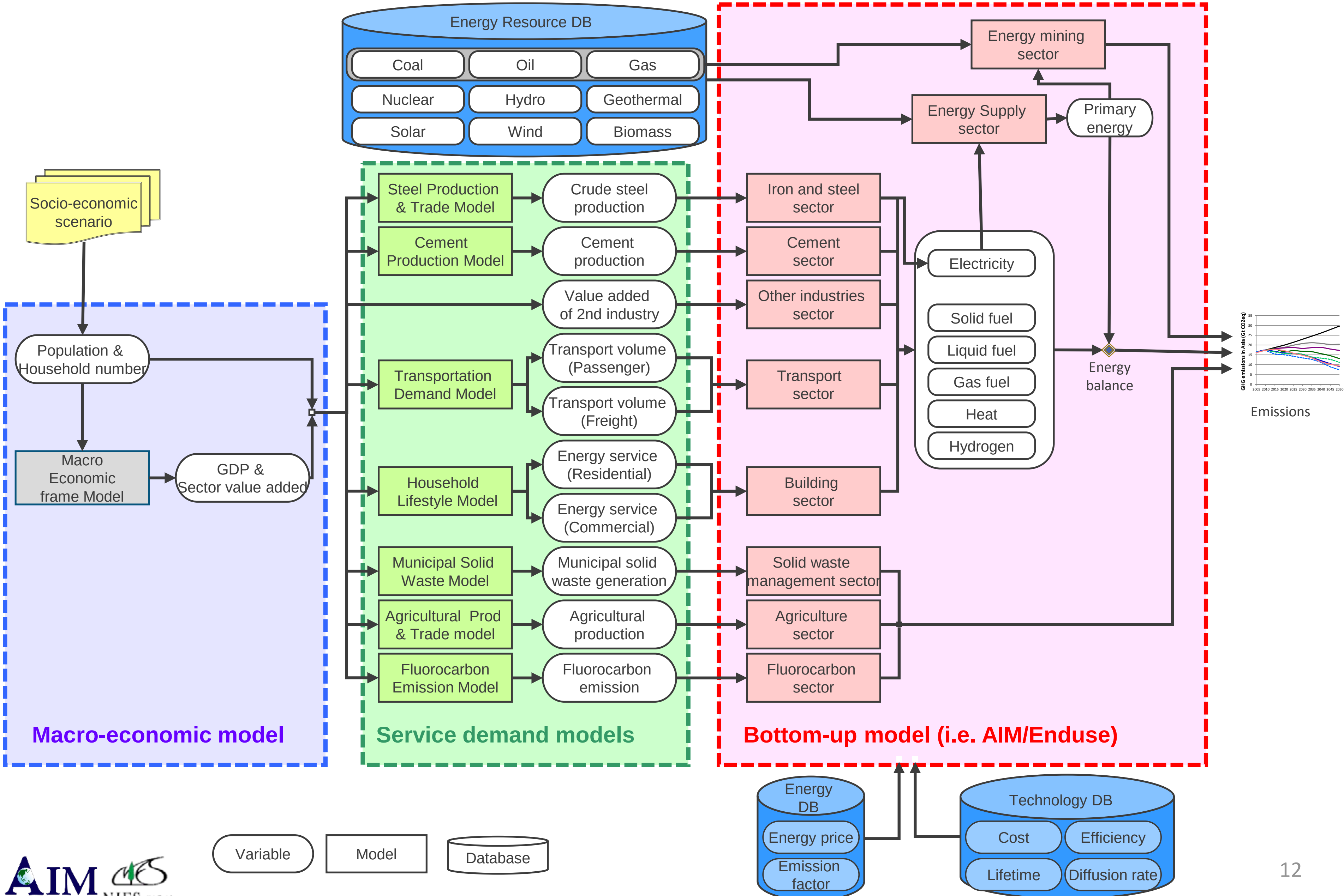
AIM/Enduse[Global] model and element models

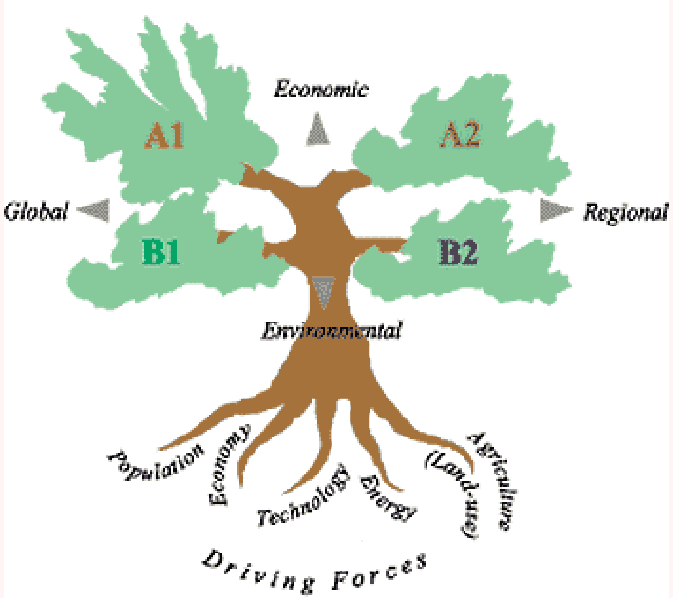


Scenario Dimensions – SSPs (Shared Socioeconomic Pathways) -

See details about quantitative data and qualitative stories
https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=about

Previous representative scenarios (until IPCC AR4)

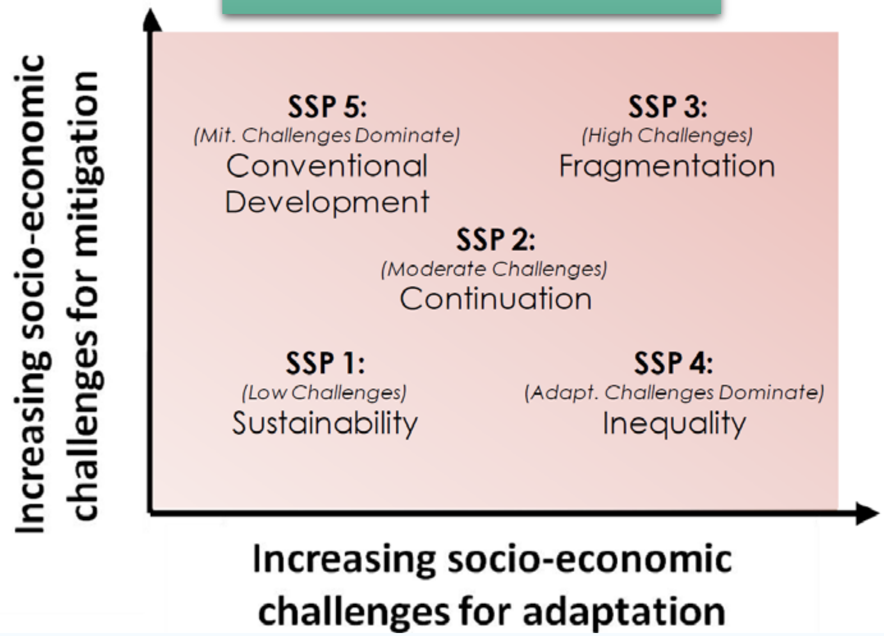
SRES



(Nakicenovic et al., 2000)

Latest representative scenarios (toward IPCC AR6)

SSPs

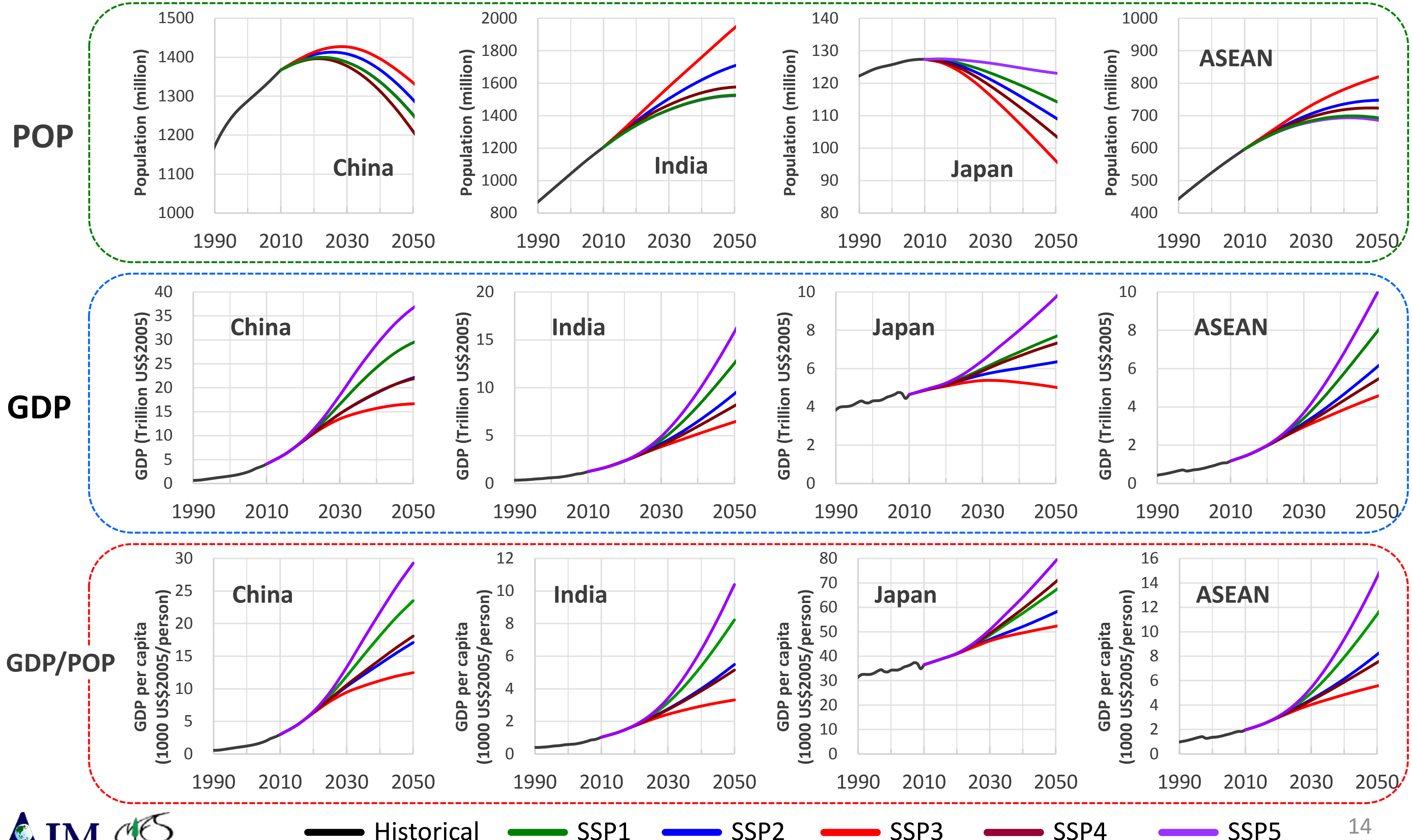


(O'Neill, 2012)

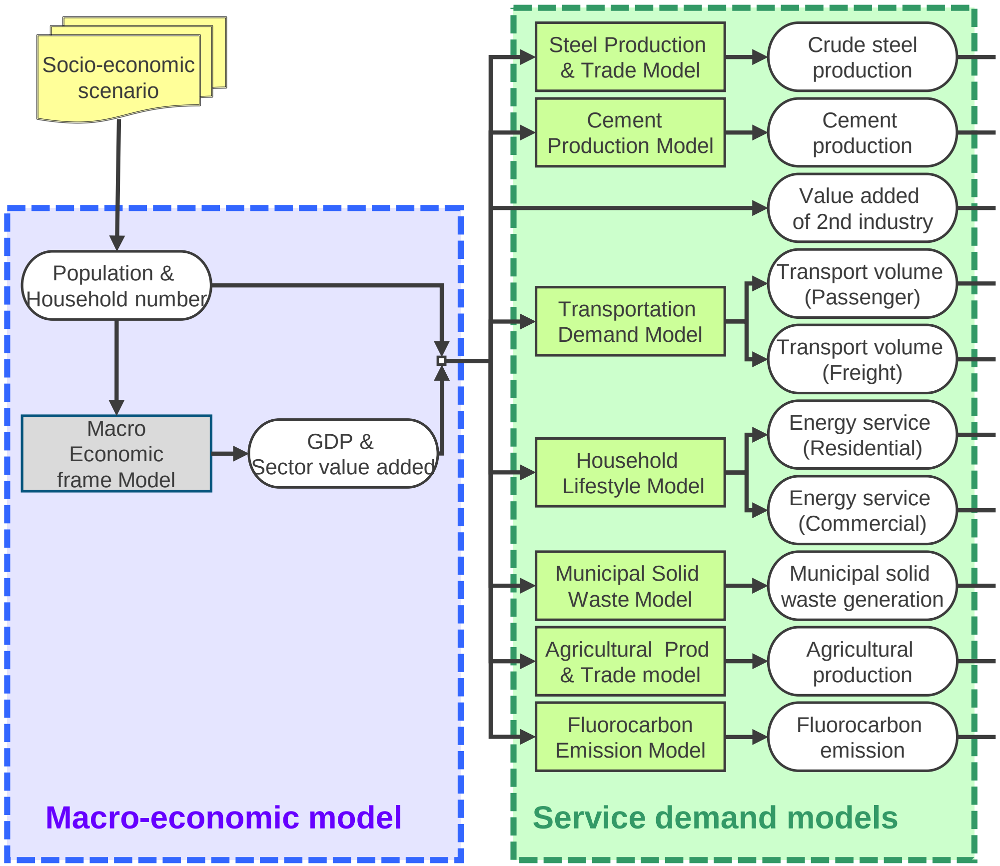
Note) peer-reviewed papers about SSP will be published soon.

Population and GDP in Asia in SSP scenarios

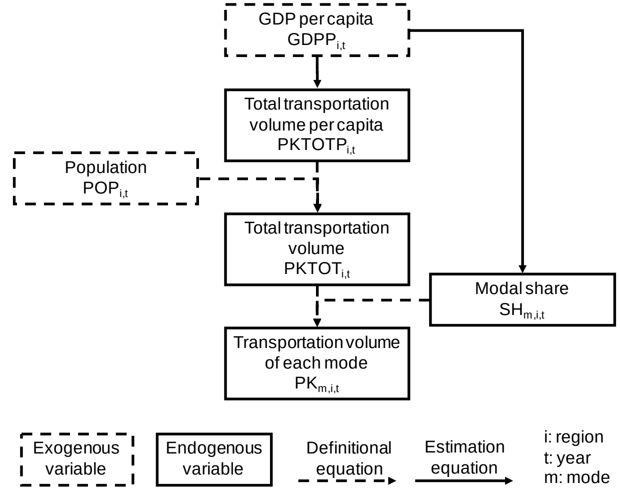
Characteristics of socio-economic dynamics are different depending on countries & scenarios
⇨ They will influence on future estimations of service demands, energy consumption,etc.



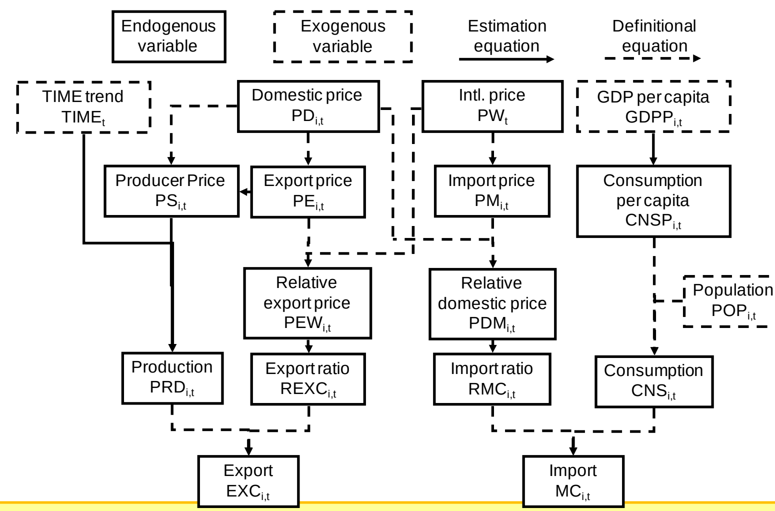
AIM/Enduse[Global] model and element models



E.g.) Passenger transport volume estimation mode



e.g.) Steel production and trade model

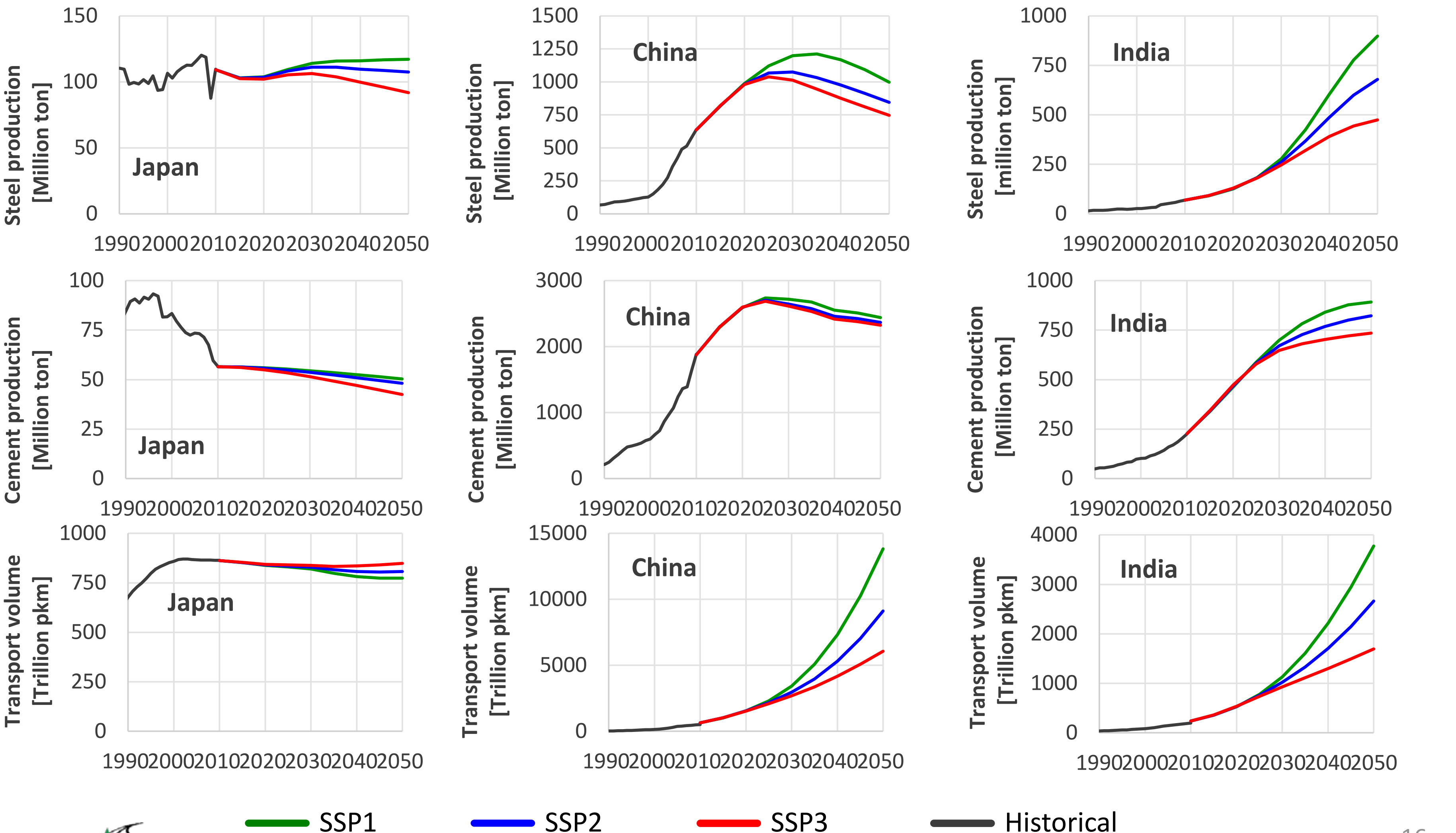


Consider socie-economic features to future service demand estimations in each sector and country (i.e. POP, GDP, are consistent across sectors and countries)

Service Demand Estimation based on SSPs

- example of energy-related sectors: major sources for CO_2, SLCPs & APs -

Future service demands are largely different by sector, country and scenario, depending on socio-economic profiles in each country.



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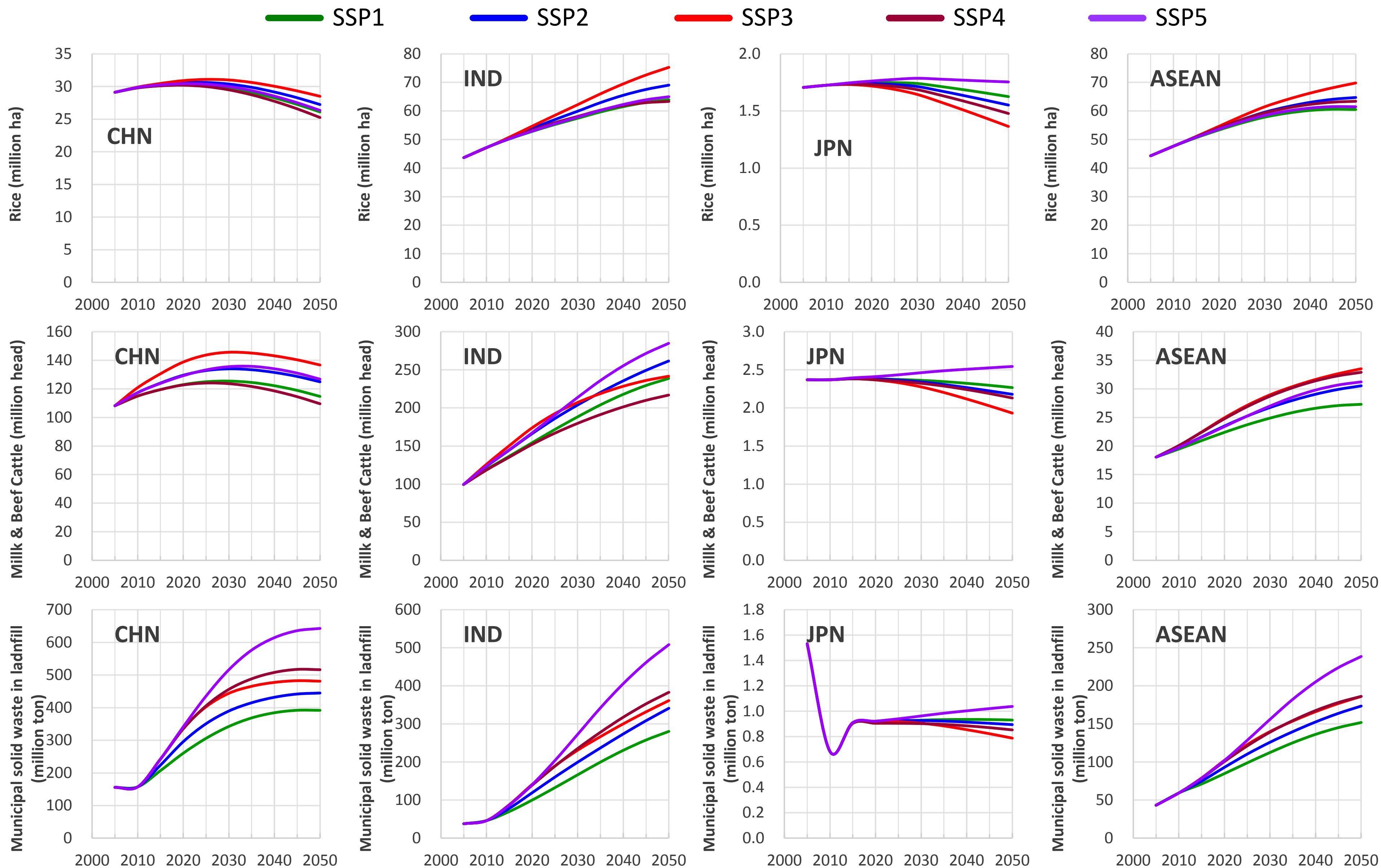
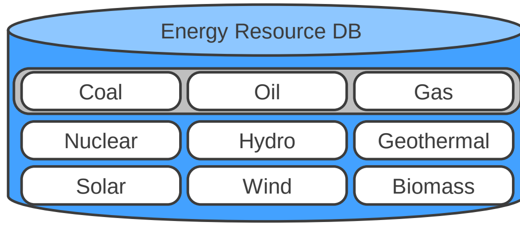
Service Demand Estimation based on SSPs

- example of non energy-related sectors: major sources for CH_4 -

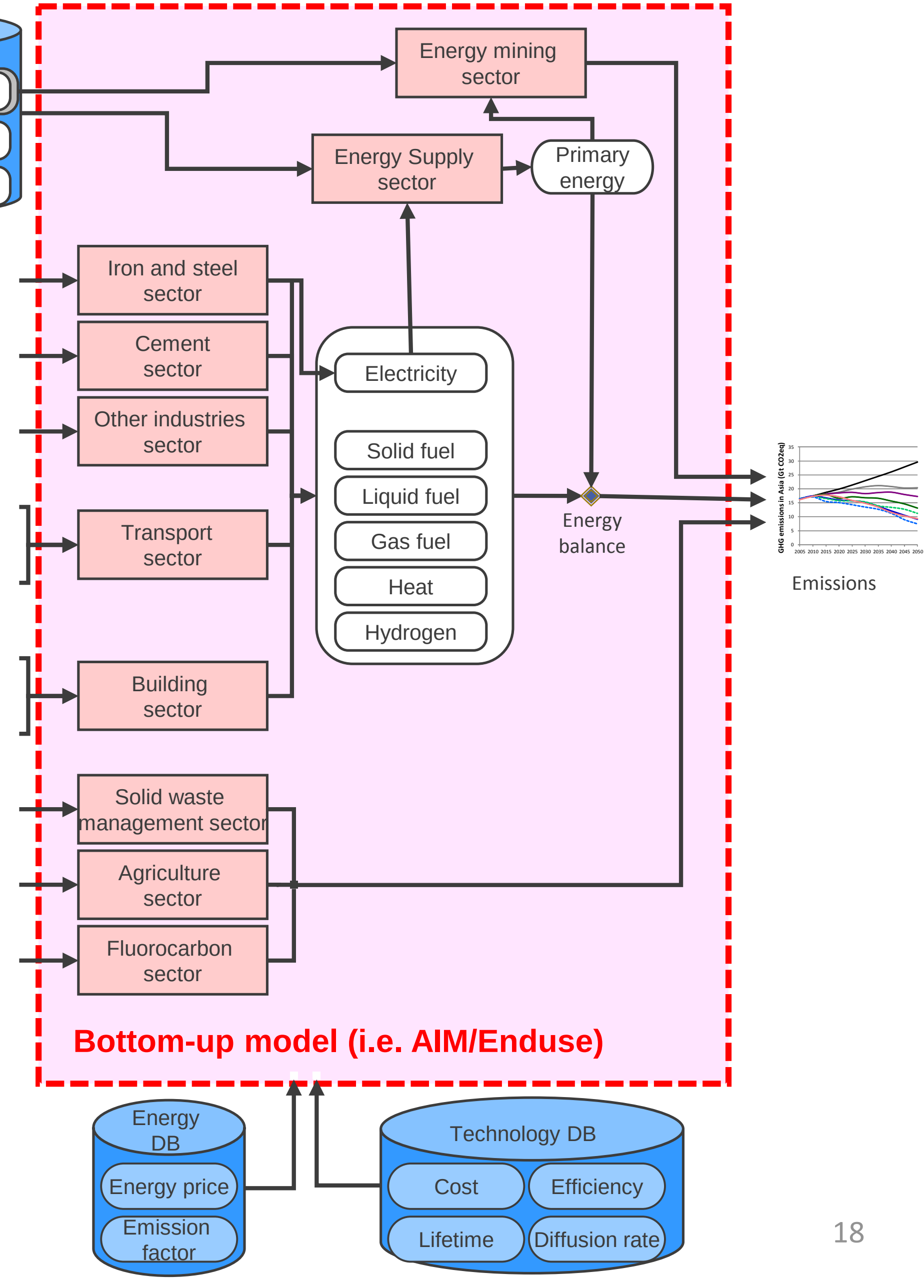


AIM/Enduse[Global] model and element models



By energy, sector and country, we can set various constraints such as

- ✓ Technology in the base year
- ✓ Energy balance in the base year
- ✓ Technology diffusion rate
- ✓ Speed of technology diffusion rate
- ✓ Technology constraints
- ✓ Energy constraints
- ✓ Speed of energy efficiency improvement
- ✓ Technology cost
- ✓ Induced technology costs etc



Select technologies to satisfy future service demands by sector and to balance supply and demand, under various constraints & under minimizing total system costs

Overview of mitigation measures

various mitigation measures are available for promoting energy efficiency on both the demand and supply side, as well as reducing air pollutant by removal devices.

Four major groups of mitigation measures on GHG and air pollutants

① **End-of-pipe mitigation measures** ⇦ Effective for reducing (a) specific gas(es)

e.g : desulfurization equipment [=SO_2 reduction], denitrification equipment [=NOx reduciton], dust-collecting equipment [=BC, PM reduction], fertilization management in agriculture [=N_2O reduciton], manure management [=CH_4, N_2O reduction], waste management [=CH_4 reduction]

② **Improvement of quality of fuels** ⇦ Effective for reducing a specific gas

e.g. : shifting from high sulfur-content fuel to low-sulfur content fuel [=SO_2 reduction]

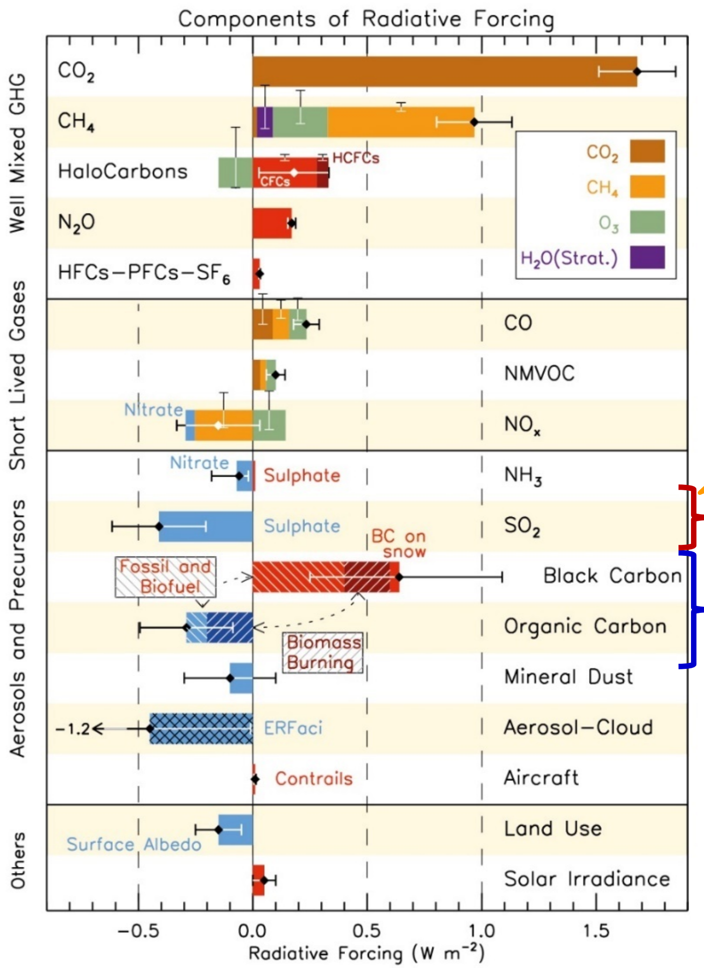
③ **Improvement of energy efficiency** ⇦ Effective for reducing multiple gases

e.g. : Introduction of high-energy efficient technologies and reduction of energy consumption [=CO_2･APs･ BC reduction], Low-carbon power in the supply side and electrification in the demand [=CO_2･APs･ BC reduction]

④ **Drastic energy shifting** ⇦ Effective for reducing multiple gases

e.g. : shifting from coal to renewables or natural gas [=CO_2･APs･ BC reduction], diffusion of hydrogen-fuel from renewables [=CO_2･APs･ BC reduction]

Seeking for Emissions Pathways of GHGs, SLCPs and APs - climate impacts of reducing SO_2 -



- **From the viewpoint of health impacts**, SO_2 should be reduced largely.
- **From the viewpoint of climate impacts**, due to local cooling effects, SO_2 should not be reduced drastically.

If low-carbon actions toward 2 °C target are taken,

- ☐ SO_2 will be reduced largely, by necessity
- ☐ Not only BC but also OC will be reduced simultaneously.

- **From the viewpoint of health impacts**, BC should be reduced largely.
- **From the viewpoint of climate impacts**, BC should be reduced largely.
- **From the viewpoint of climate impacts**, due to local cooling effects, OC should not be reduced drastically.

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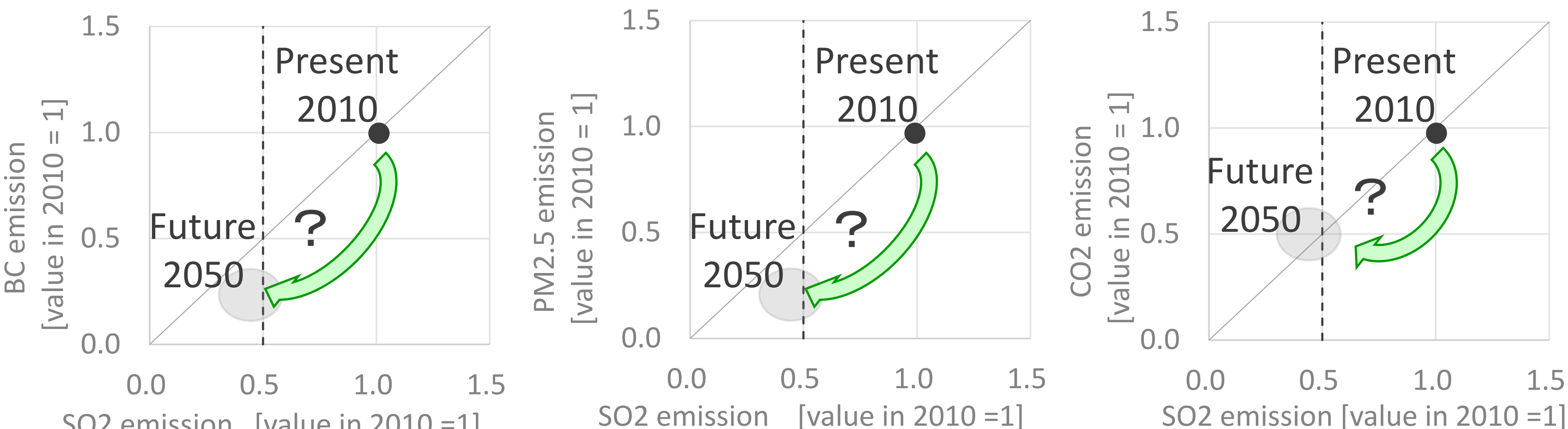
Overview of future scenario concepts in this study
- Seeking for Balance of LLGHGs, SLCPs, air pollutants emissions -

① Targeting at achieving **the 2 degree target**, as the COP21 decided

② From the viewpoint of climate impacts of positive radiative forcing, LLGHGs (CO_2, N_2O, HFCs, PFCs, SF_6) and SLCPs (CH_4, **BC**) should be reduced largely.

③ From the viewpoint of health impacts, air pollutants (**$PM_{2.5}$, SO_2, BC,** etc) should be reduced to a high enough level .

④ From the viewpoint of climate impacts of negative radiative forcing, some air pollutants (**SO_2, OC**) are preferable to be reduced only to some extent.



Overview of Scenario Settings
- Seeking for balance of LLGHGs, SLCPs, air pollutants emissions -

- Changing the settings of carbon taxes in order to discuss low-carbon society
- Changing the levels of air-pollutant control measures in order to discuss local air quality
- Changing energy policy choices: one of examples of discussing cobenefits & tradeoffs.
  - ① Promoting drastic energy shift (from high-carbon fossil fuel to less-carbon intensive fuels or renewable energies) rather than coal & biomass power plant with CCS
  - ② Allowing coal & biomass power plant with CCS rather than drastic energy shift.

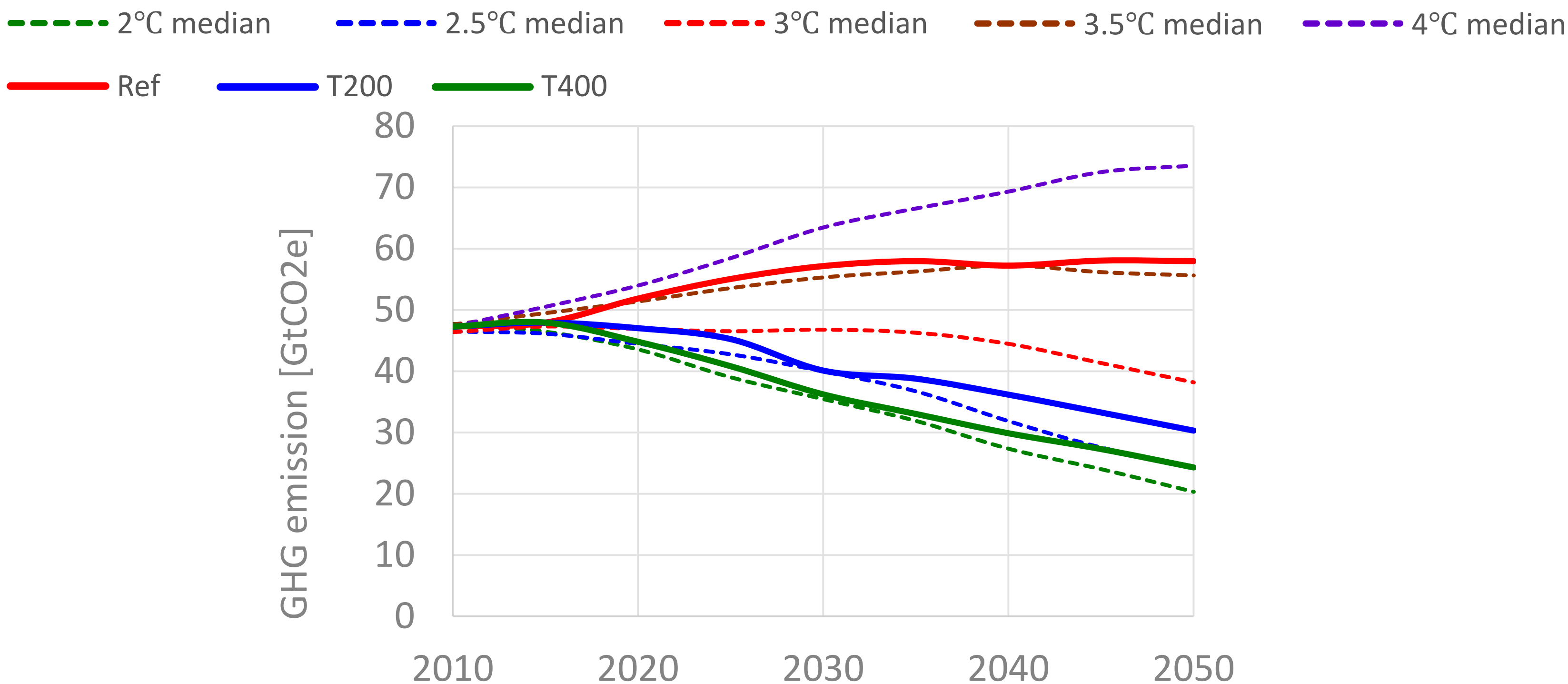
Scenario name	2010	2015	2020	2030	2040	2050	Air pollution measures	Energy policy
Reference: SSP2	0	0	0	0	0	0	SSP2 level (i.e. BaU)	SSP2 level (i.e. BaU)
T200	0	0	50	100	150	200	SSP2 level	Promoting energy shift rather than coal & biomass power with CCS
T400	**0**	**0**	**100**	**200**	**300**	**400**	SSP2 level	Promoting energy shift rather than coal & biomass power with CCS
T400ccs	**0**	**0**	**100**	**200**	**300**	**400**	SSP2 level	Allowing coal & biomass power with CCS rather than drastic energy shift
T400ccs_BCPM	**0**	**0**	**100**	**200**	**300**	**400**	SSP2 level +BCPM measure high	Allowing coal & biomass power with CCS rather than drastic energy shift
T400ccs_ALL	**0**	**0**	**100**	**200**	**300**	**400**	SSP2 level + all air pollutant measure high	Allowing coal & biomass power with CCS rather than drastic energy shift

[Unit: US$/t$CO_2$ eq]

Global Emissions pathways in this study

- comparing with a set of well-known GHG emissions pathways by the UNEP Gap Report -

- The reference scenario corresponds to the level of 3.5°C increase pathway.
- To achieve the 2°C target, future carbon price will be much higher than the current levels, around 400 US$/t$CO_2$eq in 2050



Note 1) Dashed lines show median values in the range of well-known GHG emissions pathways with a "likely" (greater than 66%) chance of staying below 2°C, 2.5°C, 3°C, 3.5°C, 4°C, compared to pre-industrial levels reported by UNEP Gap Report

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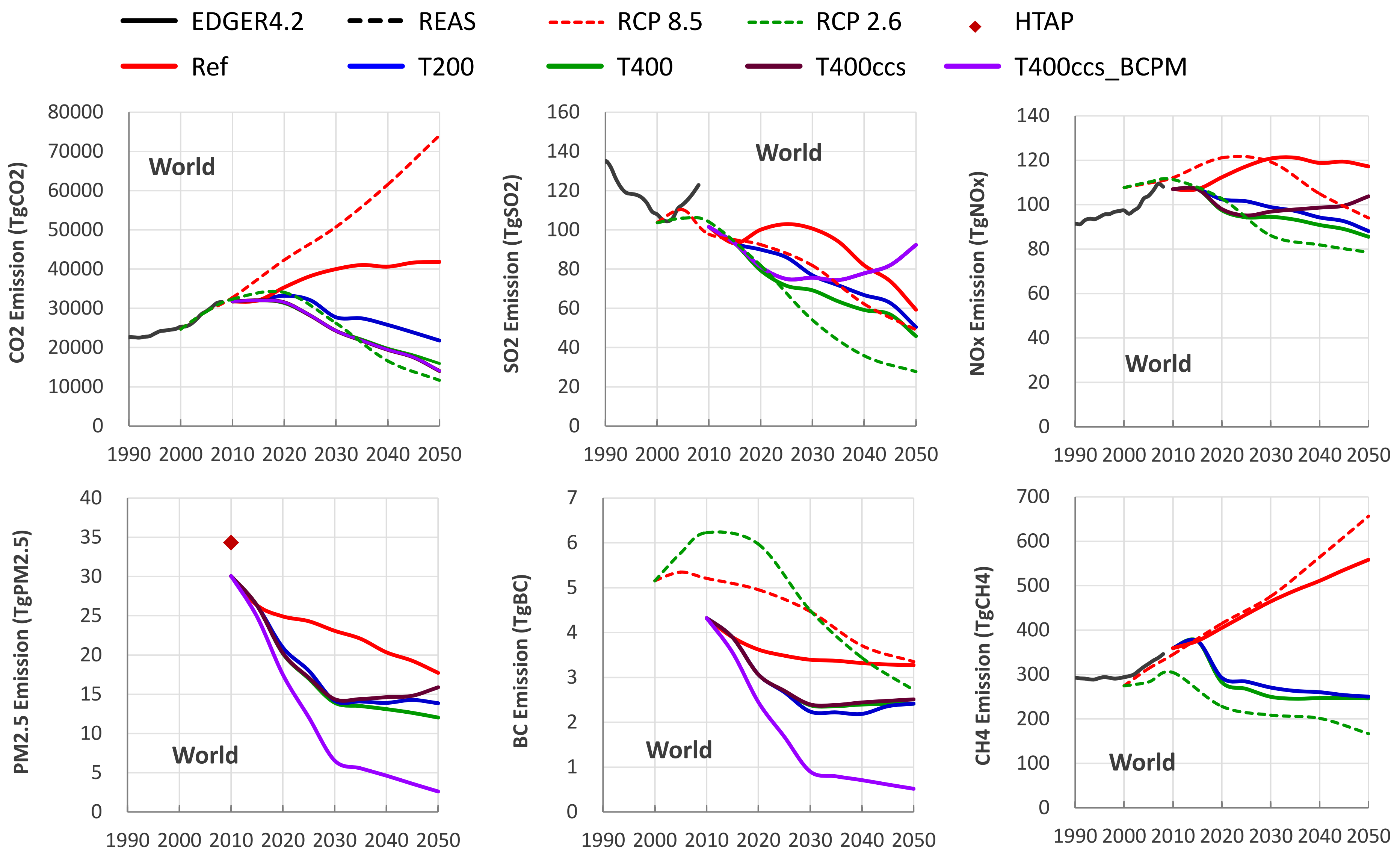
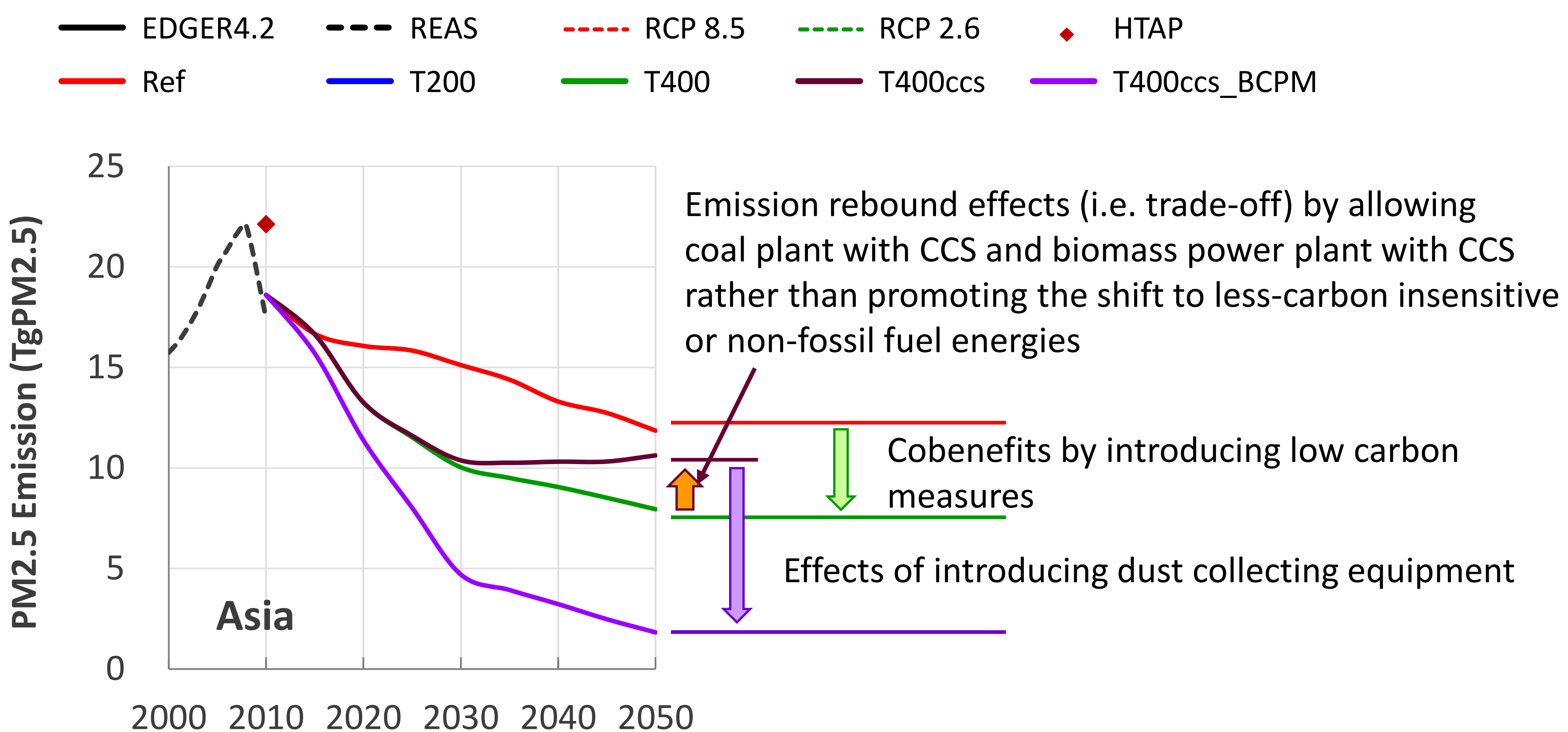
Emissions pathways of CO2, SLCPs, Air pollutants

- compared to emission inventory (EDGER, REAS, HTAP) & emissions pathways of RCP8.5, RCP2.6 -



How to interpret emissions scenarios in this study - example of $PM_{2.5}$ in Asia

- Due to low carbon measures, there are large cobenefits of reducing air pollutants.
- However, if only considering low carbon measures, there are tradeoffs (i.e. emission rebound effects) from the viewpoint of nonCO2 emissions
- Combinations of low carbon measures and nonCO2 measures are important



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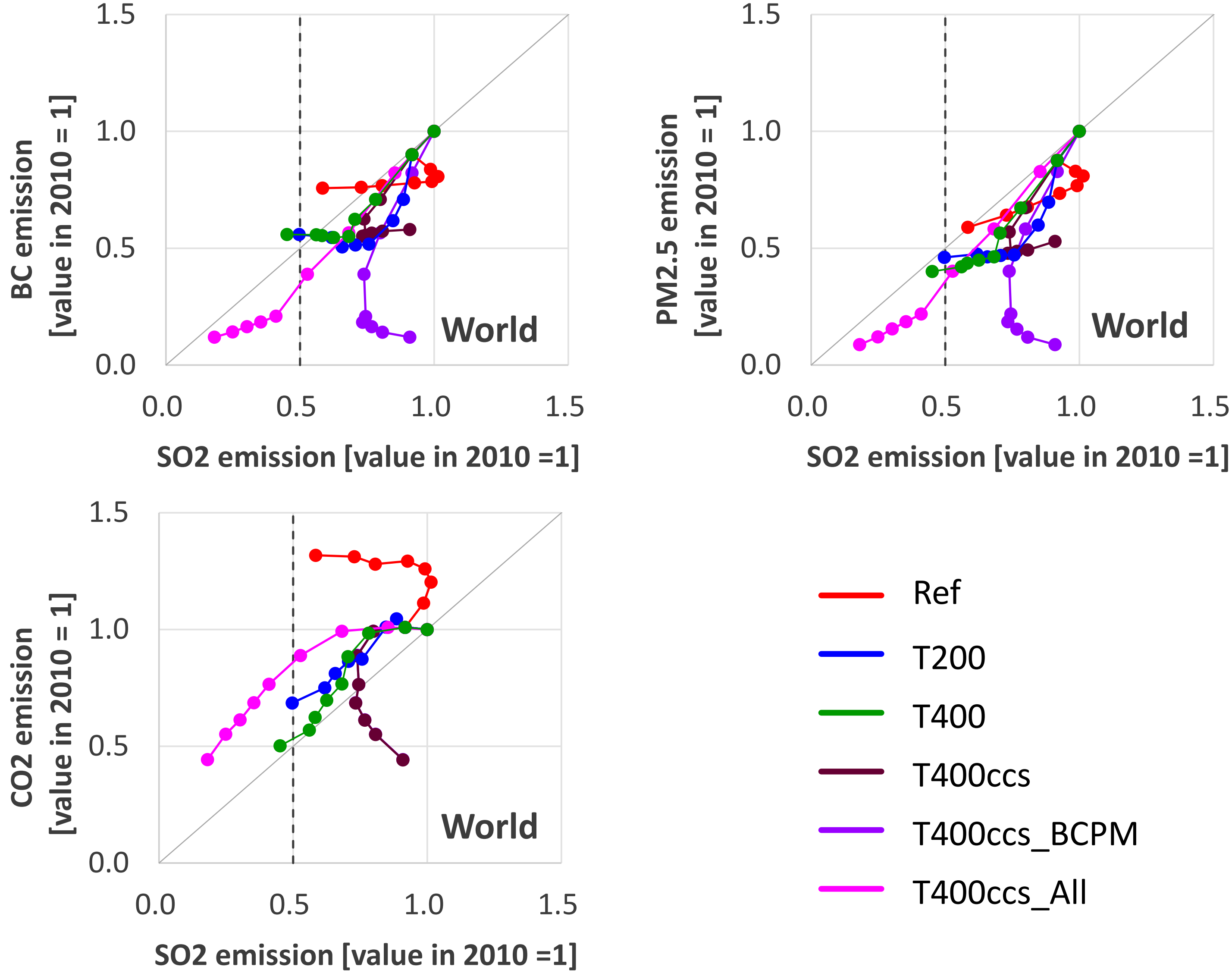
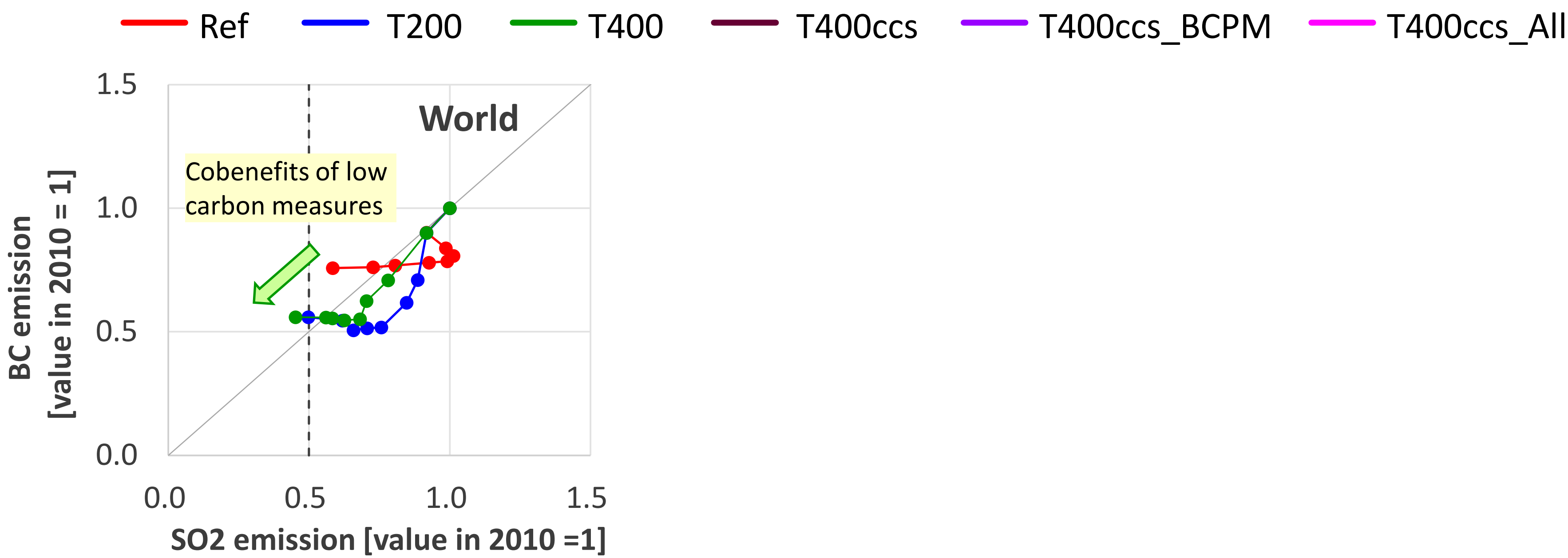
Seeking for balanced emissions pathways
- reduction ratio among GHGs, SLCPs and Air pollutions -



How to interpret the relations of relations of reducing SO2 and BC due to low carbon measures and air pollution controls



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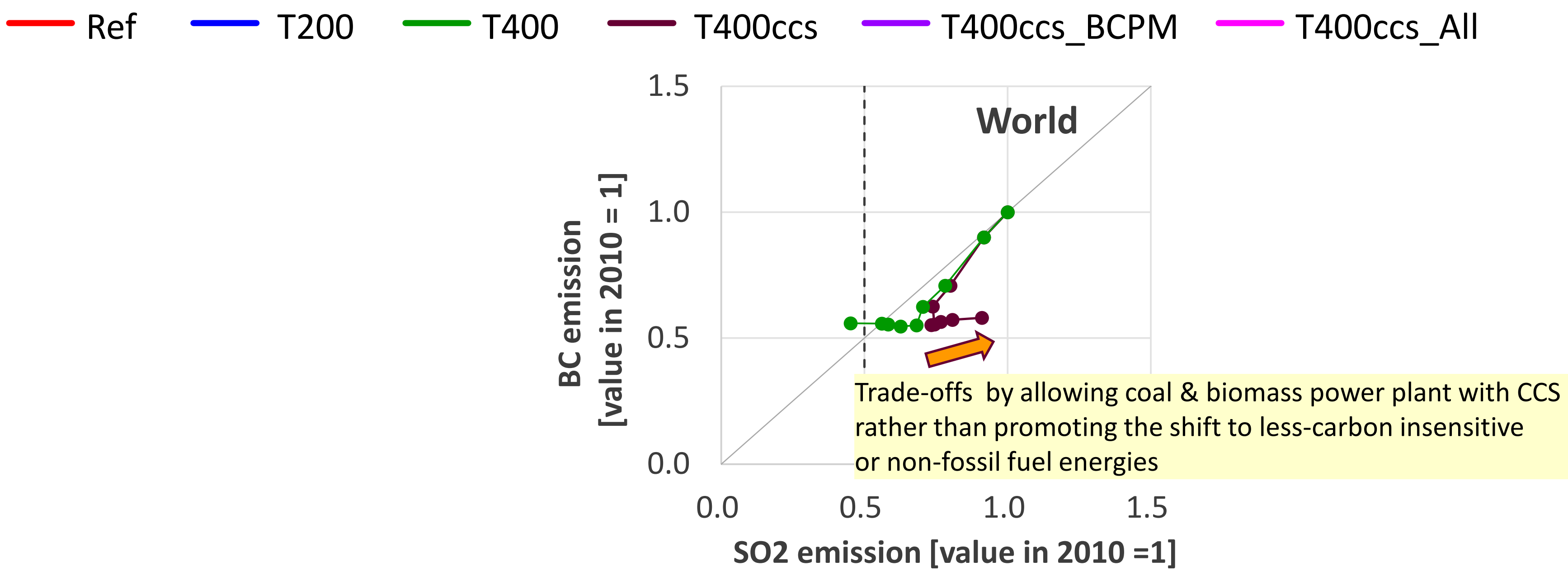

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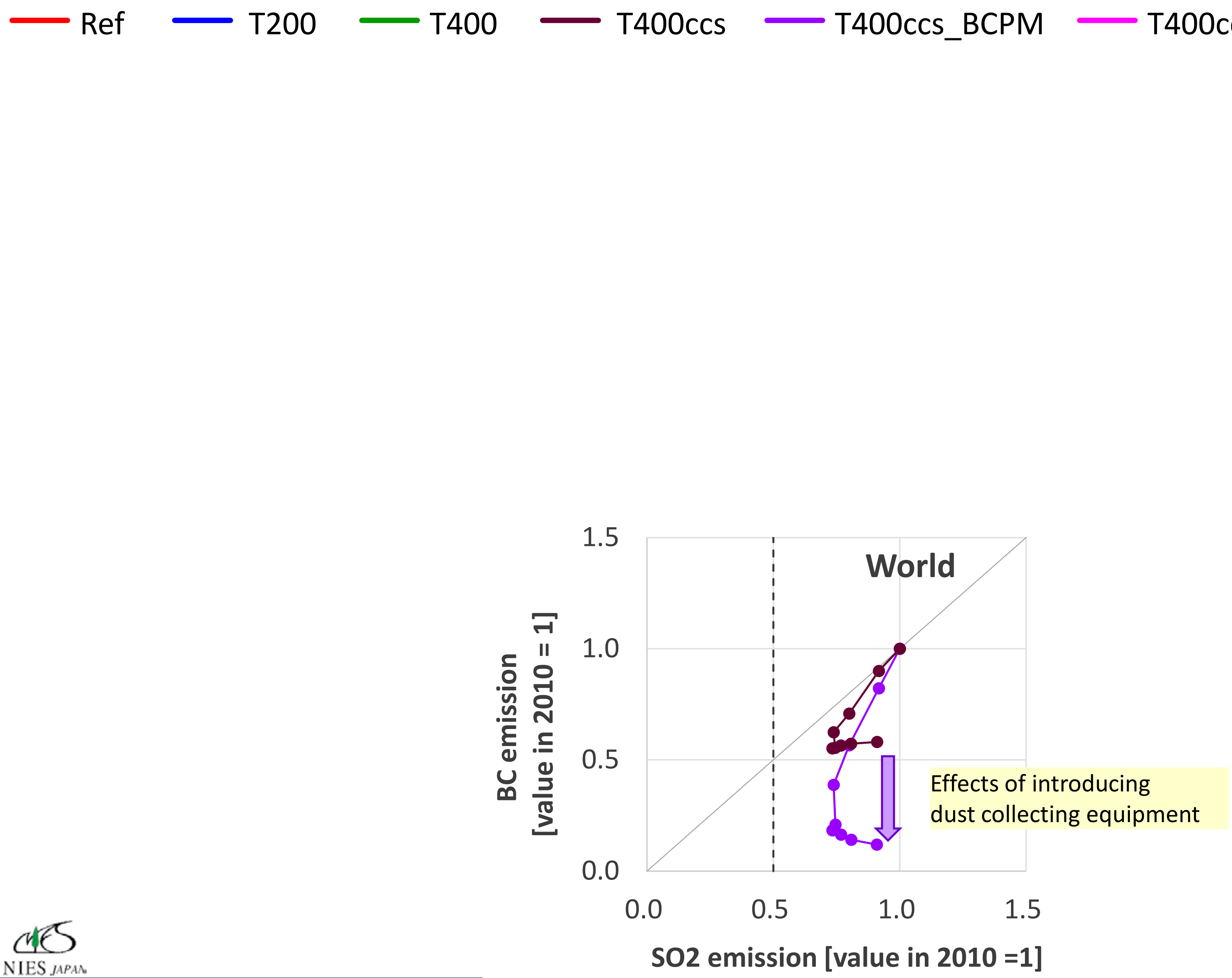

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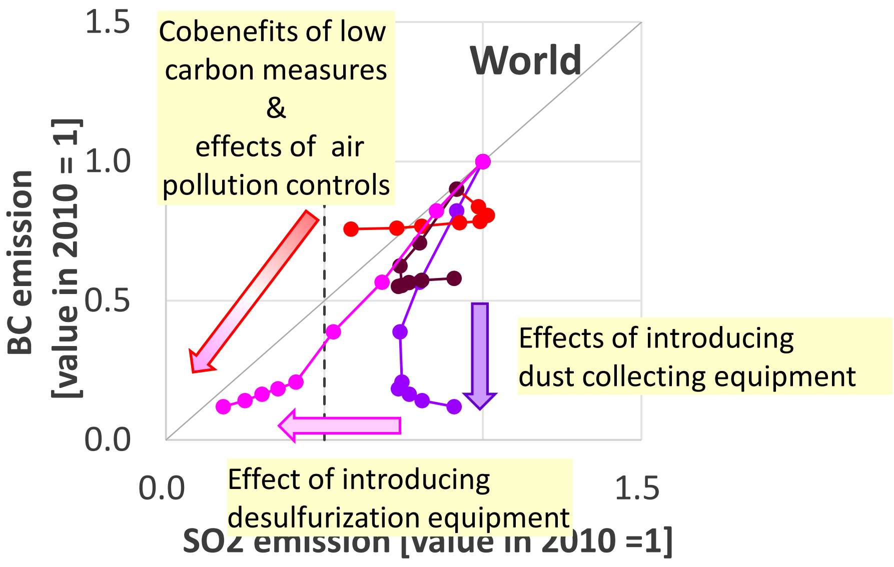

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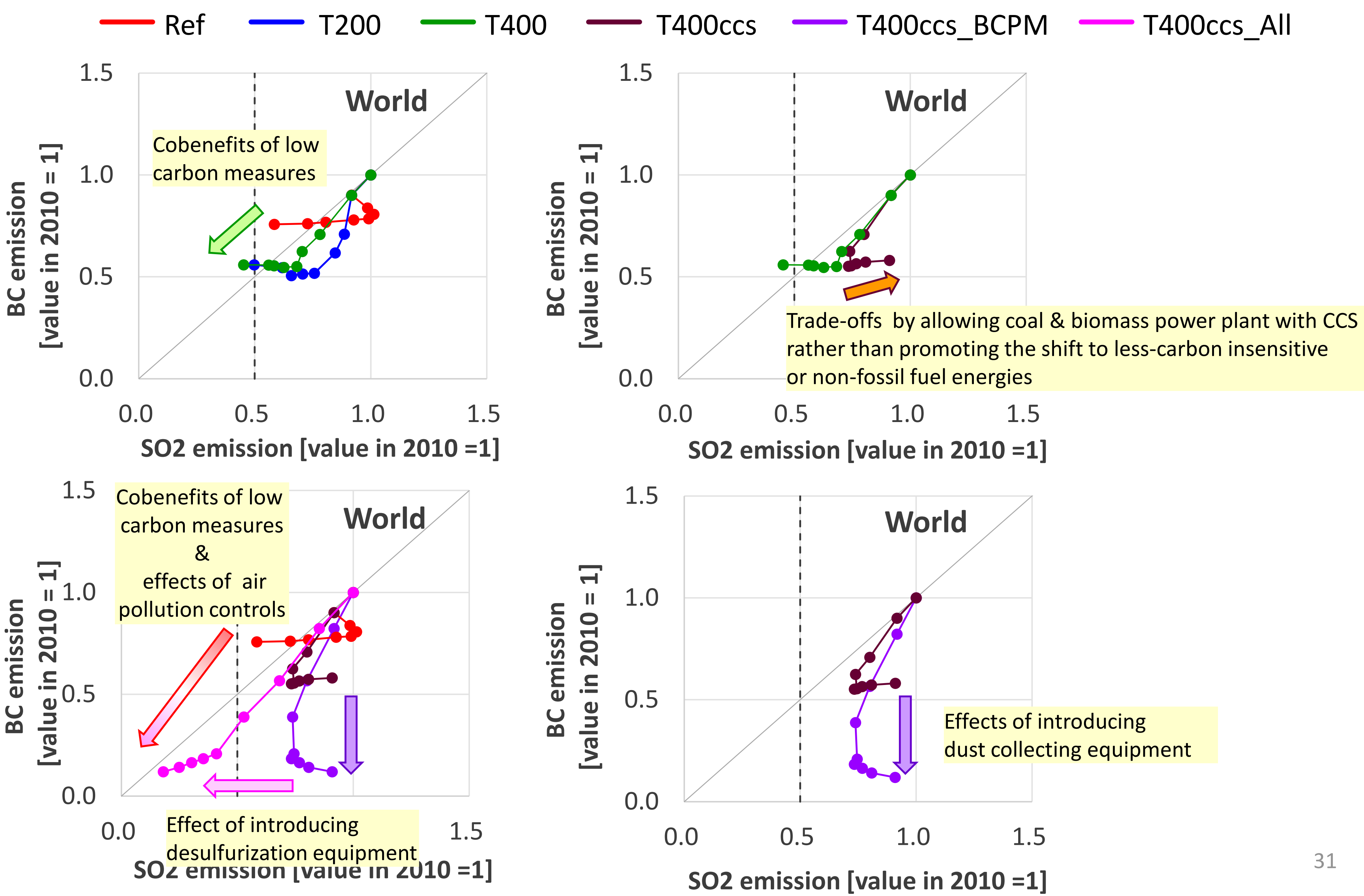

Timing is important!

ご清聴ありがとうございました

Thank you for your attention