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ALPS Project – Studies on Policies and Measures for Climate Change and Sustainable Development toward Green Growth

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Background and Objective of ALPS project

ALPS: FY2007-2011; ALPSII: FY2012-

- **The world is facing various challenges to be addressed, while global warming is surely an important issue.**
- **It is really important to achieve such multiple objectives with well-balanced priorities, in order to improve present and future generations well-being.**
- **High economic growth is expected in developing countries, at least, until the middle of 21st century.**
- **"Green growth" will be required for climate change measures to be implemented continuously for the long time.**
- **Consistent analyses for climate change and other sustainable development challenges are required to seek better future.**

- **This study aimed to present consistent and quantitative analyses for climate change and sustainable development.**

ALPS: ALternative Pathways toward Sustainable development and climate stabilization

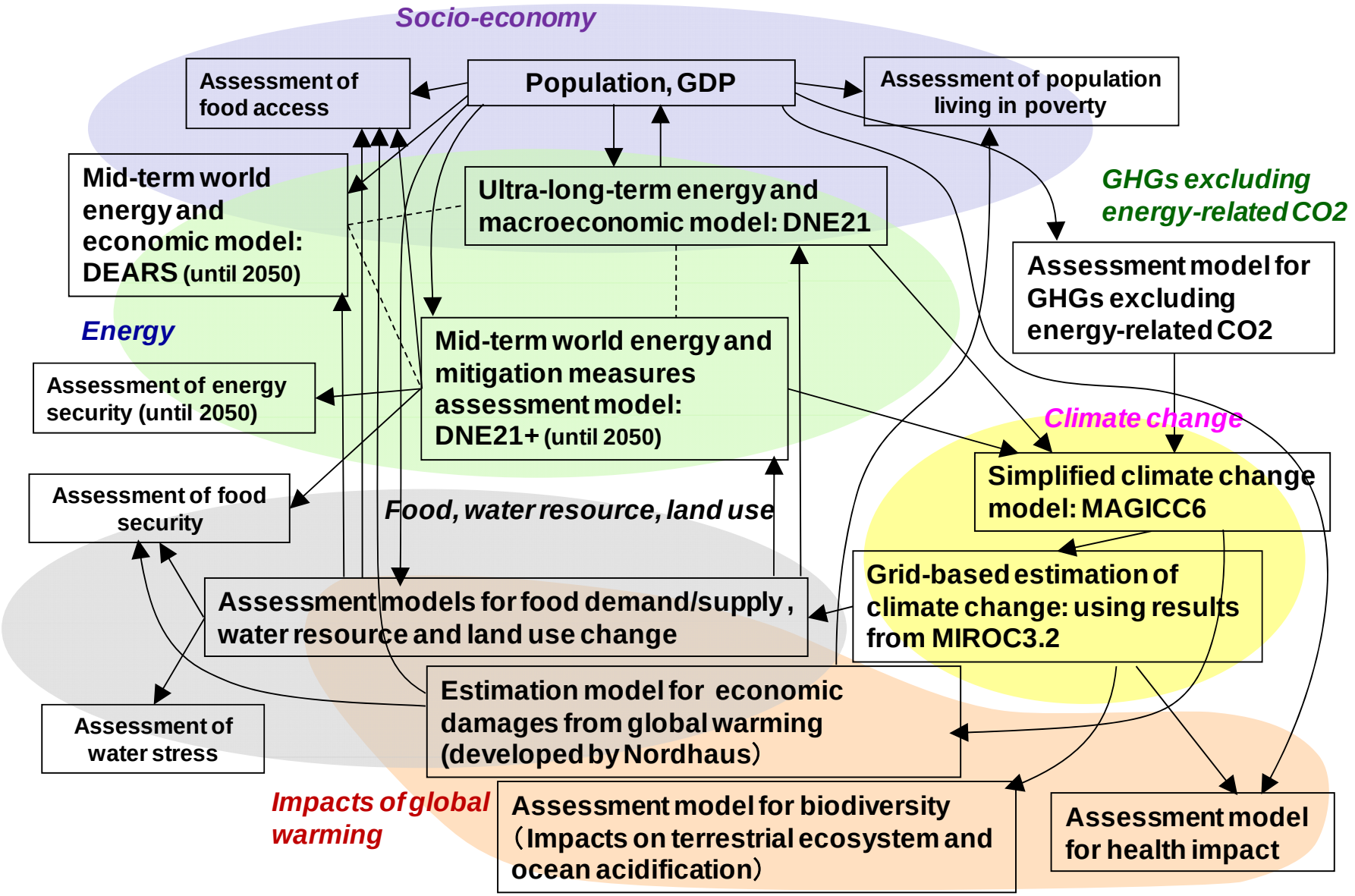
Working Package of ALPSII

How to achieve “green growth” in the real world

[WP]

- **Risk management of climate change, e.g., how to develop risk management strategy of mitigation, and adaptation with geoengineering in consideration; long-term climate goals**
- **Economy: better understanding of and exploring a possible narrow path to green growth; gathering and analyses of related data**
- **Technology: diffusion and development, proposals and analyses of effects of integration of various technologies including co-benefit; e.g., smart grid, smart city, hydrogen systems**
- **Model development and analyses from perspectives of technology, economy and sustainable development**

Relationships among Models for Consistent Scenario Analysis



Energy Assessment Model: DNE21+

- Linear programming model (minimizing world energy system cost)
- Evaluation time period: 2000-2050
  Representative time points: 2000, 2005, 2010, 2015, 2020, 2025, 2030, 2040, 2050
- World divided into 54 regions
  Large area countries are further divided into 3-8 regions, and the world is divided into 77 regions.
- Bottom-up modeling for technologies both in energy supply and demand sides (200-300 specific technologies are modeled.)
- Primary energy: coal, oil, natural gas, hydro&geothermal, wind, photovoltaics, biomass and nuclear power
- Electricity demand and supply are formulated for 4 time periods: instantaneous peak, peak, intermediate and off-peak periods
- Interregional trade: coal, crude oil, natural gas, syn. oil, ethanol, hydrogen, electricity and CO_2
- Existing facility vintages are explicitly modeled.

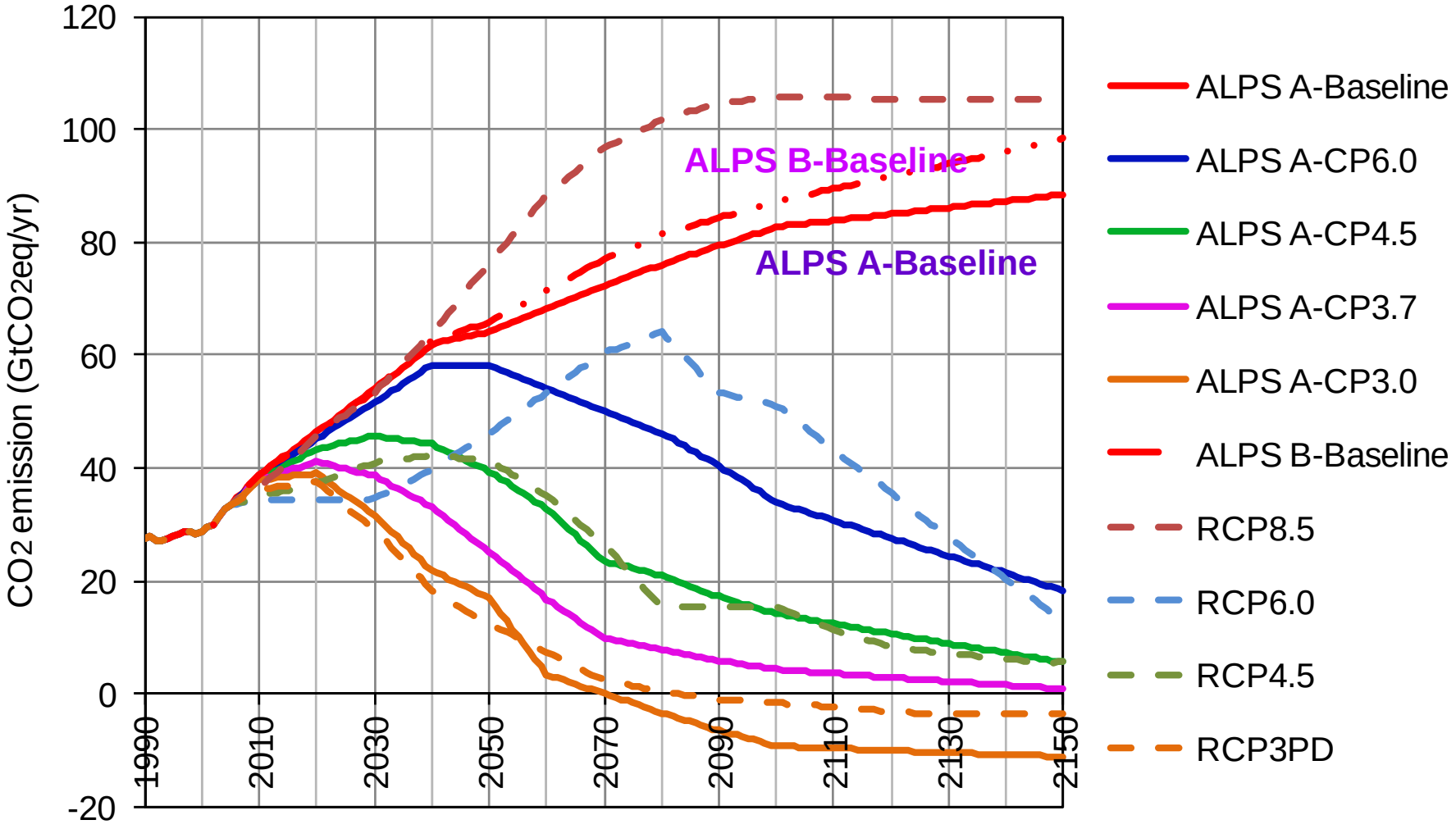
- The model has detailed information in regions and technologies enough to analyze sectoral approach.
- Consistent analyses among regions and sectors can be conducted.

Consistent Analyses for Climate Change and Sustainable Development

Assessed Major Indicator

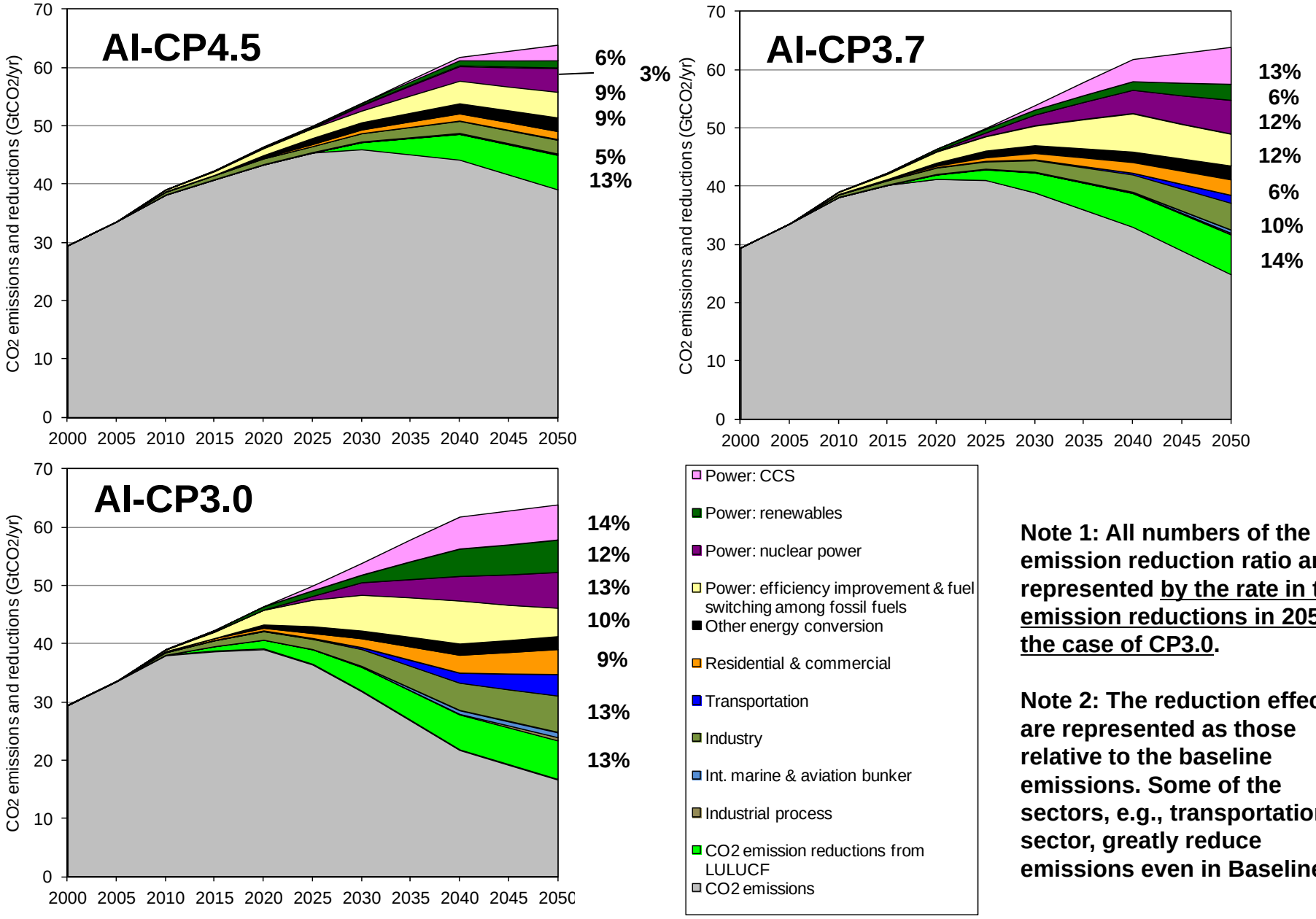
Category	Indicator
Economic and poverty	Income (GDP per capita)
	People living in poverty (including impacts of climate change and mitigation measures)
	Food access (amount of food consumption per GDP) (including impacts of climate change and mitigation measures)
	Energy access (access to grid electricity; People relying on the traditional use of biomass for cooking)
Agriculture, land-use, and biodiversity	Agriculture land area (including impacts of climate change)
	Food security (amount of food imports per GDP) (including impacts of climate change and mitigation measures)
Water	People living under water stress (including impacts of climate change)
Energy	Sustainable energy use (cumulative fossil fuel consumption)
	Energy use efficiency (primary energy consumption per capita and per GDP)
	Energy security (share of total primary energy consumption accounted for by oil and gas imports with country risks)
Climate change	Economic impact of mitigation measures (marginal abatement cost (carbon price) and GDP loss)
	Global mean temperature change
	Aggregated economic impact of climate change

ALPS CO2 Emission Scenarios



Note: CO2 emissions including those from industrial processes and LULUCF
RCP (Representative Concentration Pathway): IPCC new scenario

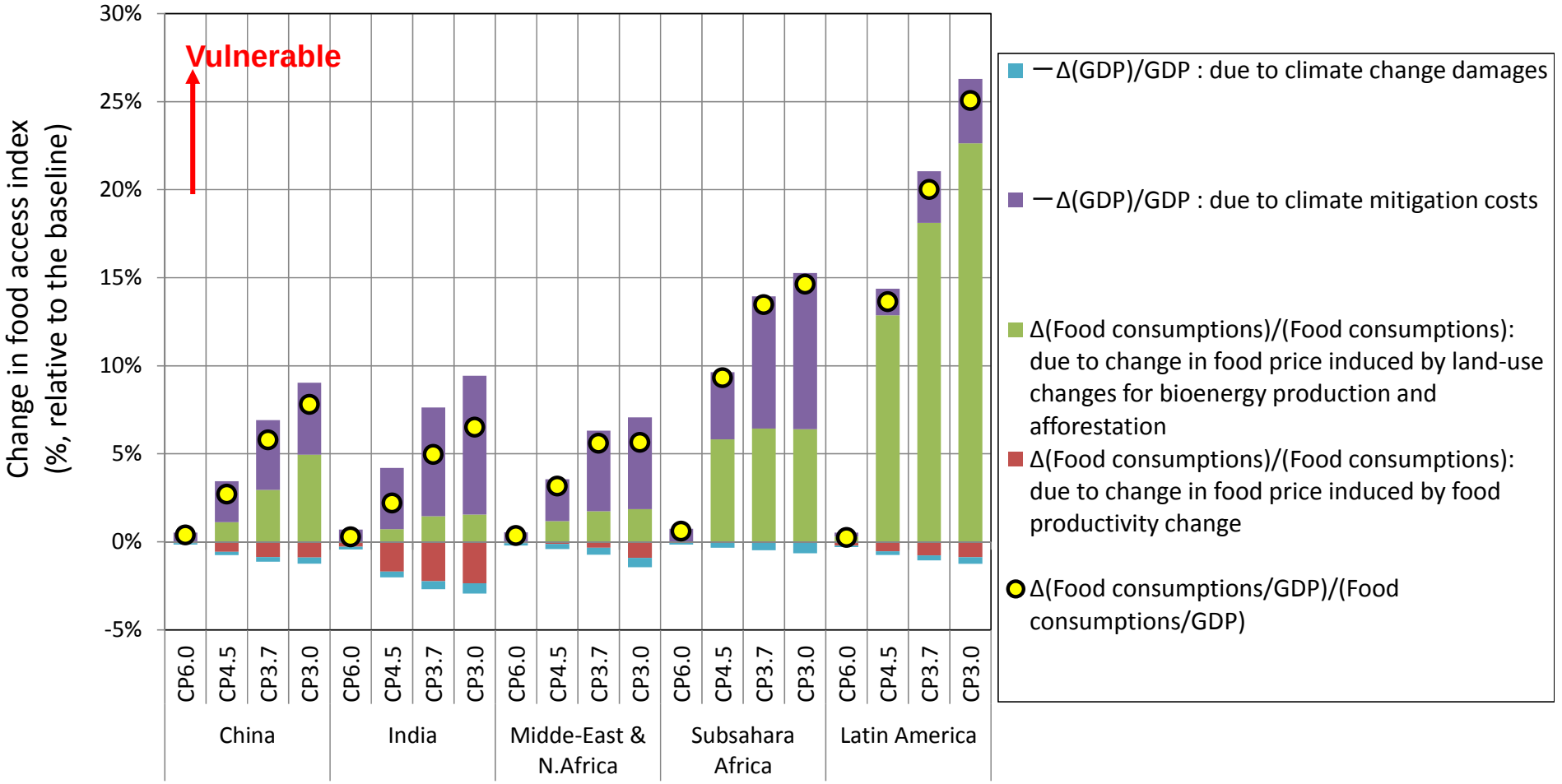
CO_2 Emission reductions by Sector and Technology



Note 1: All numbers of the emission reduction ratio are represented <u>by the rate in total emission reductions in 2050 in the case of CP3.0</u>.

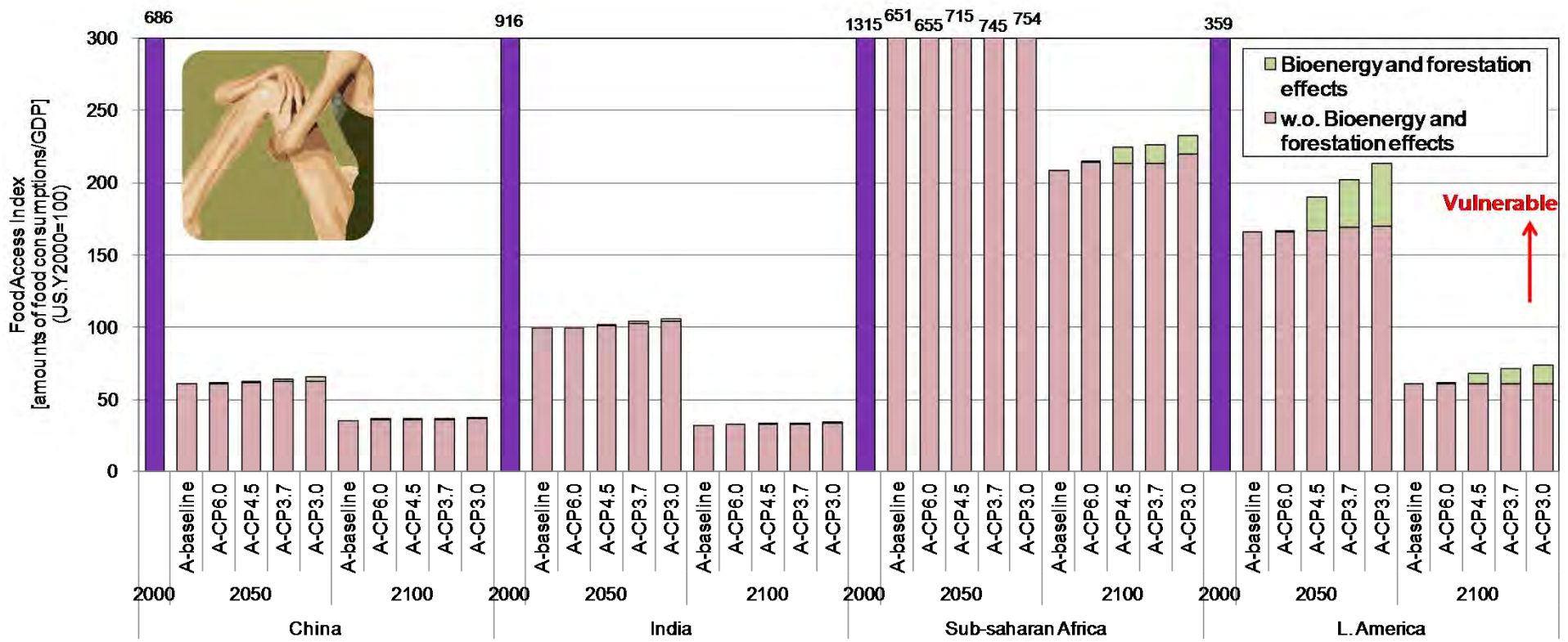
Note 2: The reduction effects are represented as those relative to the baseline emissions. Some of the sectors, e.g., transportation sector, greatly reduce emissions even in Baseline.

Impacts on Food Access Index by Factor in 2050



Deeper emission reduction will improve food access (decrease the food access index) due to smaller climate change damages on aggregated economy and food productivities, but will deteriorate food access (increase the index) due to decrease in GDP by mitigation costs and food price increase induced by bioenergy production and afforestation.

Food Access Indicator
(Amounts of food consumption per GDP)



Vulnerabilities of food access will decrease in most countries and regions in the long-term under any emission scenarios, because future incomes are expected to increase.

Global warming impacts on food productions are relatively small compared with the effects of income increase.

Global warming counter-measures of large scale forestation and bioenery use slightly increase vulnerabilities of food access.

For Better Understanding and Analyses of End-use Technologies and their Diffusions

Technology Learning

category	technology	data for: cumulative production (units)	#	exp	*period*	Learning rates
energy end-use	Transitors	World	>1	10^18	*1960-2010*	40
	DRAMs	World	>1	10^11	*1975-2005*	16 - 24
	Automobiles	World	>2	10^9	*1900-2005*	9 - 14
	Washing machines	World	>2	10^9	*1965-2008*	33 ±9
	Refrigerators	World	>2	10^9	*1964-2008*	9 ±4
	Dishwashers	World	>6	10^8	*1968-2007*	27 ±7
	Freezers (upright)	World	>6	10^8	*1970-2003*	10 ±5
	Freezers (chest)	World	>5	10^8	*1970-1998*	8 ±2
	Dryers	World	>3	10^8	*1969-2003*	28 ±7
	Hand-held calculators	US	>4	10^8	*early 1970s*	30
	CF light bulbs	US	>4	10^8	*1992-1998*	16
	A/C & heat pumps	US	>1	10^8	*1972-2009*	18 ±1
	Air furnaces	US	>1	10^8	*1953-2009*	31 ±3
	Solar hot water heaters	US	>1	10^6	*1974-2003*	-3
	average for end-use technologies			10^9		20
energy supply	PV modules	World	>1	10^10	*1975-2009*	18-24
	Wind turbines	World	>1	10^5	*1975-2009*	10-17
	Heat pumps	S, CH	<1	10^5	*1982-2008*	2 - 21
	Gas turbines	World	>4	10^4	*1958-1980*	10-13
	Pulverized coal boilers	World	>6	10^3	*1940-2000*	6
	Hypropower plants	OECD	~5	10^3	*1975-1993*	1
	Nuclear reactors	US, France	<1	10^3	*1971-2000*	-20 - -47
	Ethanol	Brazil	<1	10^3	*1975-2009*	21
	Coal power plants	OECD	<1	10^3	*1975-1993*	8
	Coal power plants	US	<1	10^3	*1950-1982*	1 - 6
	Gas pipelines	US	<1	10^3	*1984-1997*	4
	Gas combined cycles	OECD	<1	10^3	*1981-1997*	10
	Hydrogen production (SRM)	World	>1	10^2	*1980-2005*	27
	LNG production	World	>1	10^2	*1980-2005*	14
	average for suppy technologies					8
	average for supply, excluding nuclear			10^4		12

Higher learning rates are observed.

Source: IIASA report (2013)

Supply-side vs End-use and Large-scale vs Small-scale Technologies

- **Supply-side technologies:**
  [Role] supply energies
  Energy supply cost is a determinant factor to the welfare for the same kind of secondary energy regardless of the kind of original primary energy.

- **End-use technologies:**
  [Role] supply end-use products or services
  Production or service cost compared with our welfare increase is an important factor for preference changes induced by innovations: high (e.g., cathode-ray TV -> LCD TV)

- **Large-scale technologies: lower speed of diffusions**
  lifetime: long; technology learning: slow; technology innovation: slow

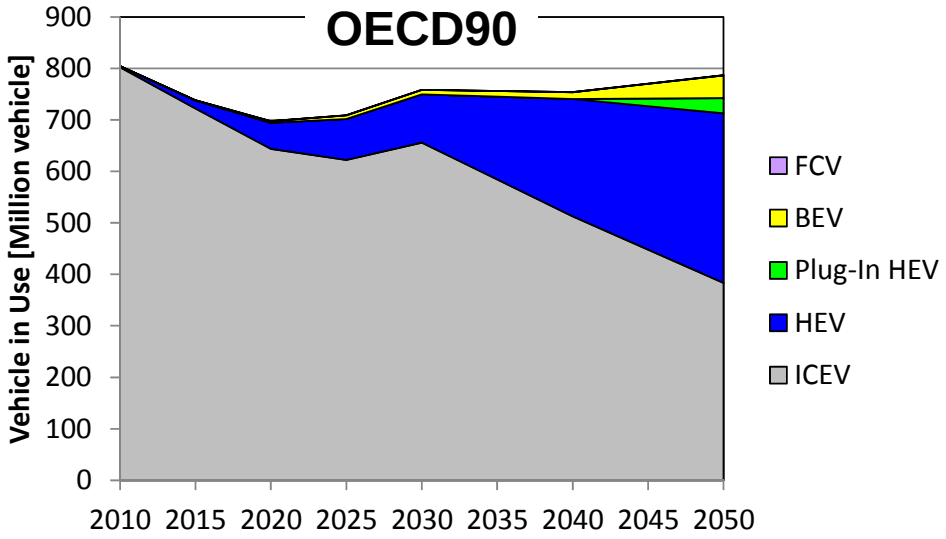
- **Small-scale technologies: higher speed of diffusions**
  lifetime: short; technology learning: high; technology innovation: high

Assumed discount rate by sector (tentative)

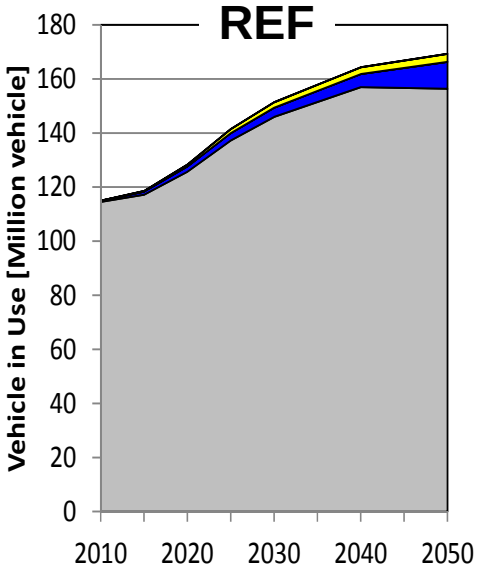
Sector	Discount rate
Electricity generation	8-20%
Other energy conversion	15-25%
Industry (Energy intensive industry)	15-25%
Transport (Road)	30-45%
Residential and Commercial	30-55%

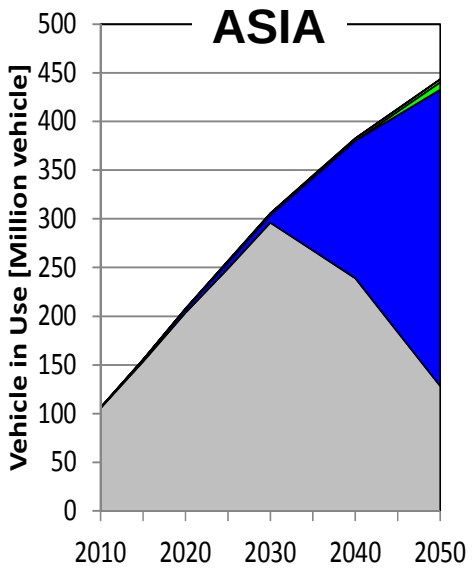
- **Discount rates for different regions and different time points are assumed to be within the ranges, depending on the region's per-capita GDP.**
- **Small passenger car (< 2,000cc) users are divided into two groups: purchasers preferring environment conscious products and to regular products. The purchasers preferring environment conscious products adopts 10% discount rate.**

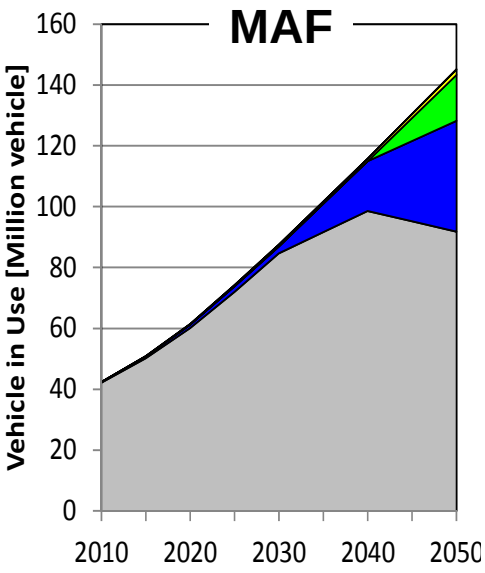
Technology deployments of passenger cars to developing countries (ALPS-3.0W/m² Case) (tentative)

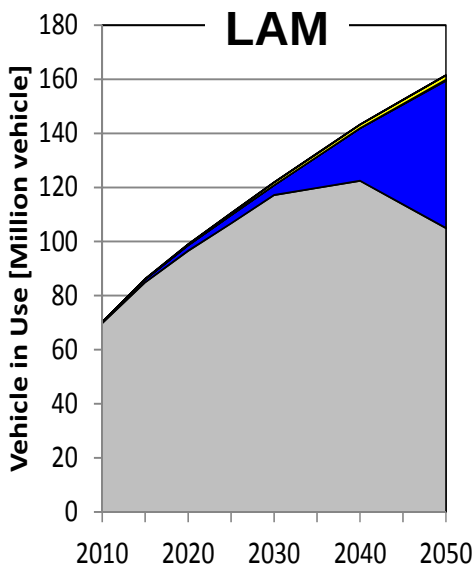


Diffusion of HEV is started in OECD90. According to cost reductions of HEV and discount rate improvements in other regions, HEV is adopted also in other regions such as ASIA.

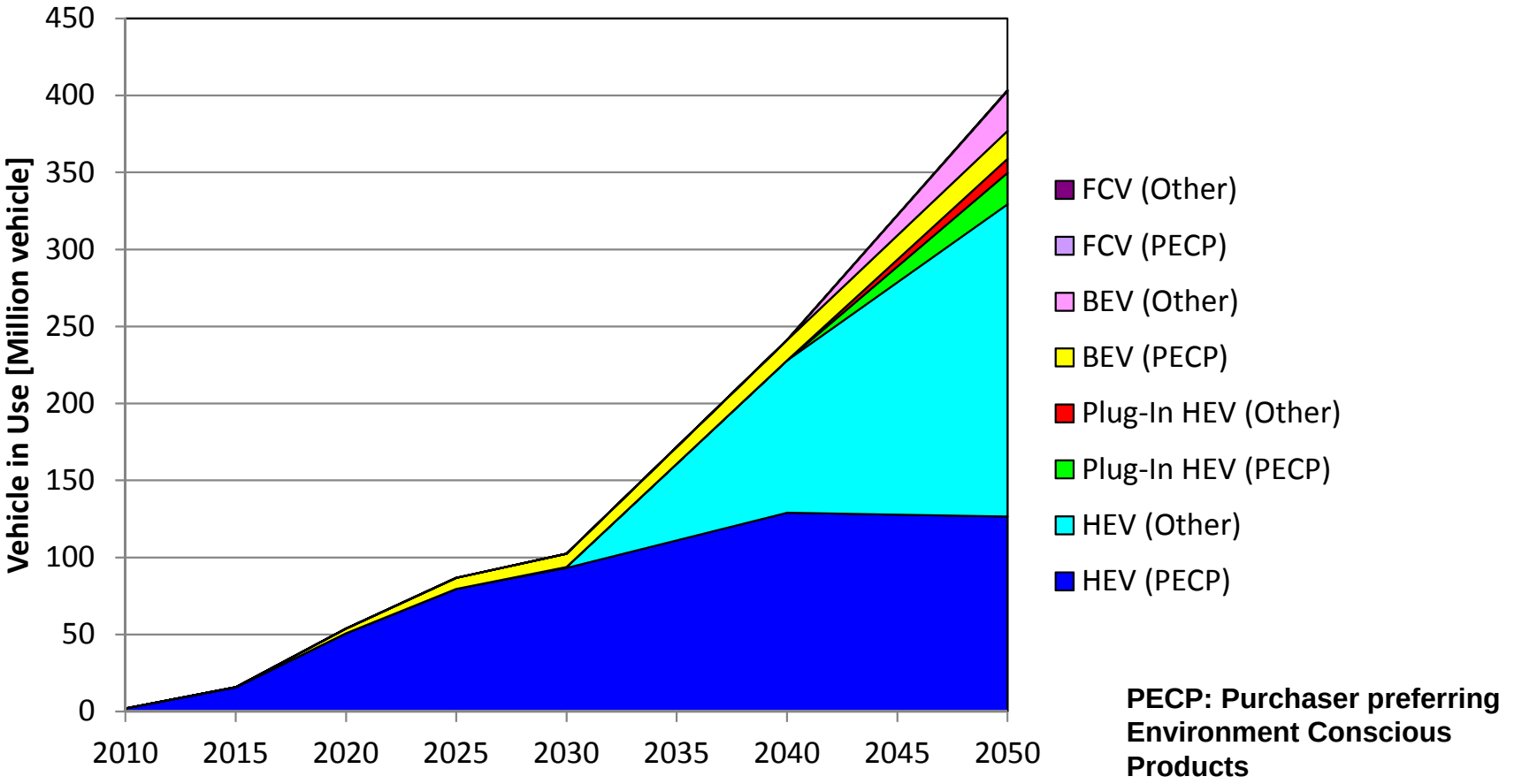








Technology deployments of environment compatible passenger cars within OECD90 (ALPS-3.0W/m^2 Case) (tentative)



PECP: Purchaser preferring Environment Conscious Products

- **Purchasers preferring environment conscious products adopt new technologies such as HEV at early stage of their diffusion.**

International Symposium of ALPS Project

The international symposiums for better understandings for climate change and sustainable development have been held in Tokyo every years since 2002 (from PHOENIX project).

A few researchers from IIASA participated in all the symposiums. Particularly Prof. Nakicenovic kindly participated in almost all the symposiums.

FY2013 ALPS Symposium

(at Tokyo International Forum, on Feb. 4, 2014; about 240 attendees)

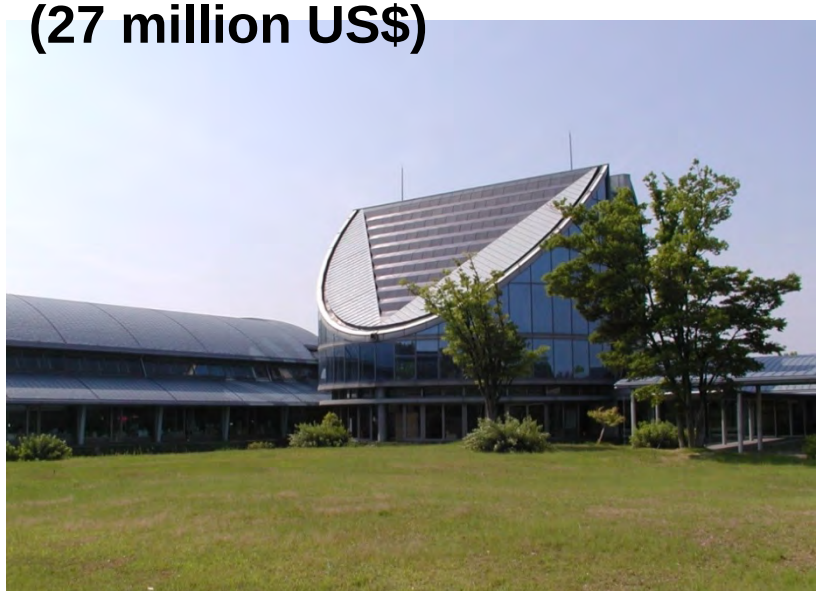
FY2014 ALPS Symposium will be held on February 27, 2015.

Prof. Nakicenovic will kindly give a lecture also this physical year!

Appendix I:
Overview of RITE

Basic Information about RITE

- Mission : R&D of industrial technologies that contribute to the conservation of the global environment and the progress of the world economy
- Established in July 1990 (Supported by MITI, local governments, academic circles and industries)
- Location : Kansai Science City (Kyoto, Japan)
- Activities : Development of innovative environmental technologies for CO2 mitigation
- Staffs : 175 (April 1, 2014)
- Annual budget : Approx. 2.7 billion JPY (27 million US$)
- President: Prof. Yoichi Kaya
- Director general: Prof. Kenji Yamaji



Research Staffs in Systems Analysis Group

As of April 2014

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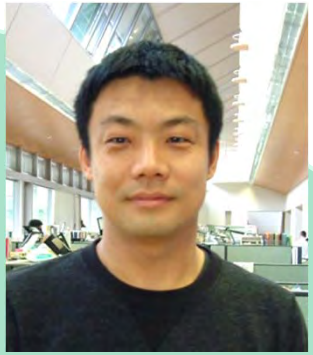

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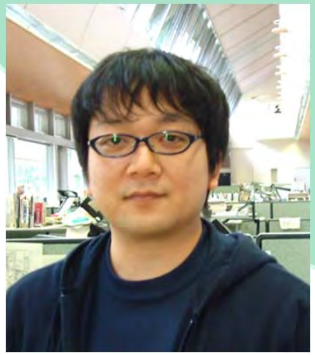

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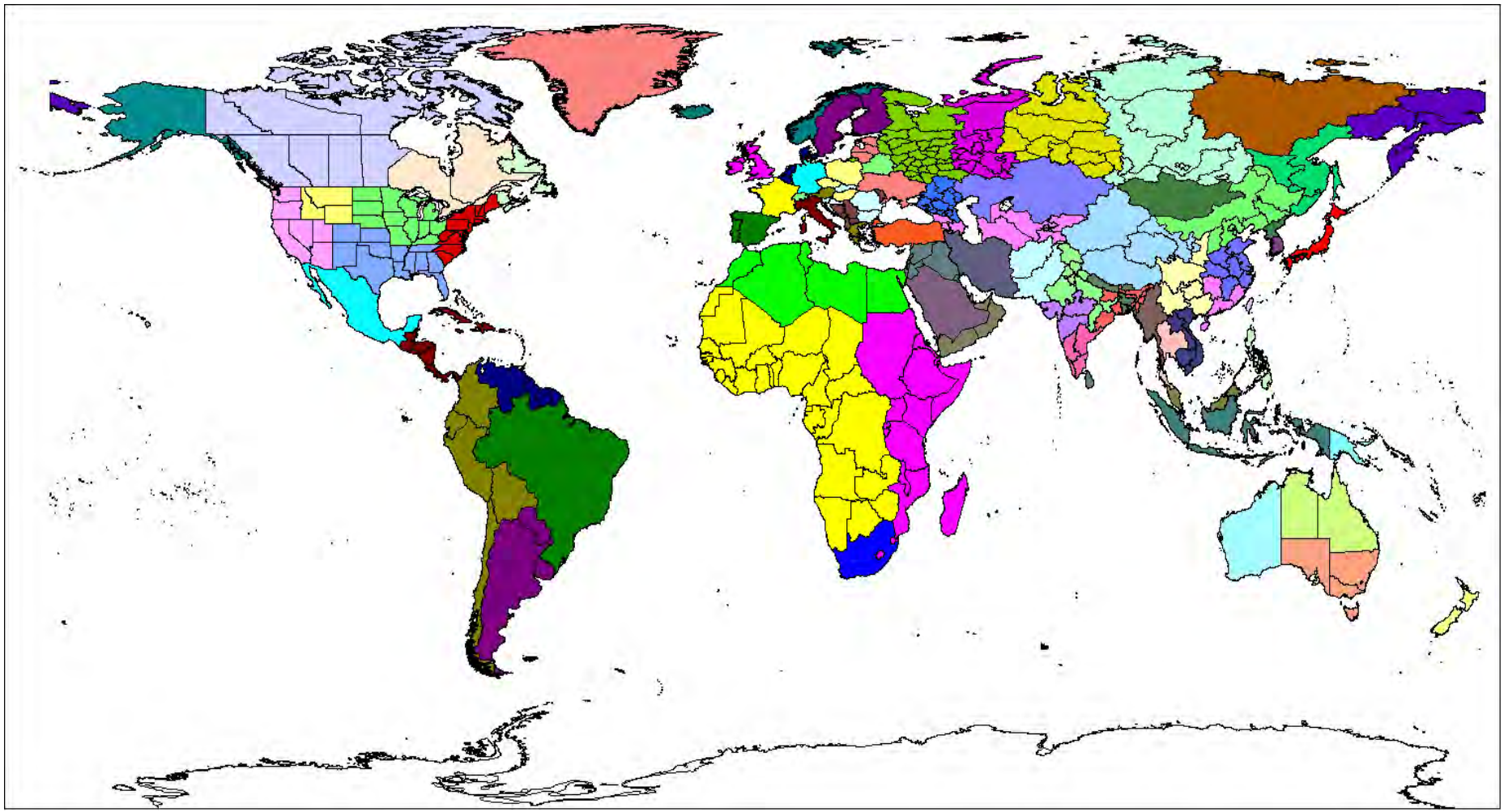
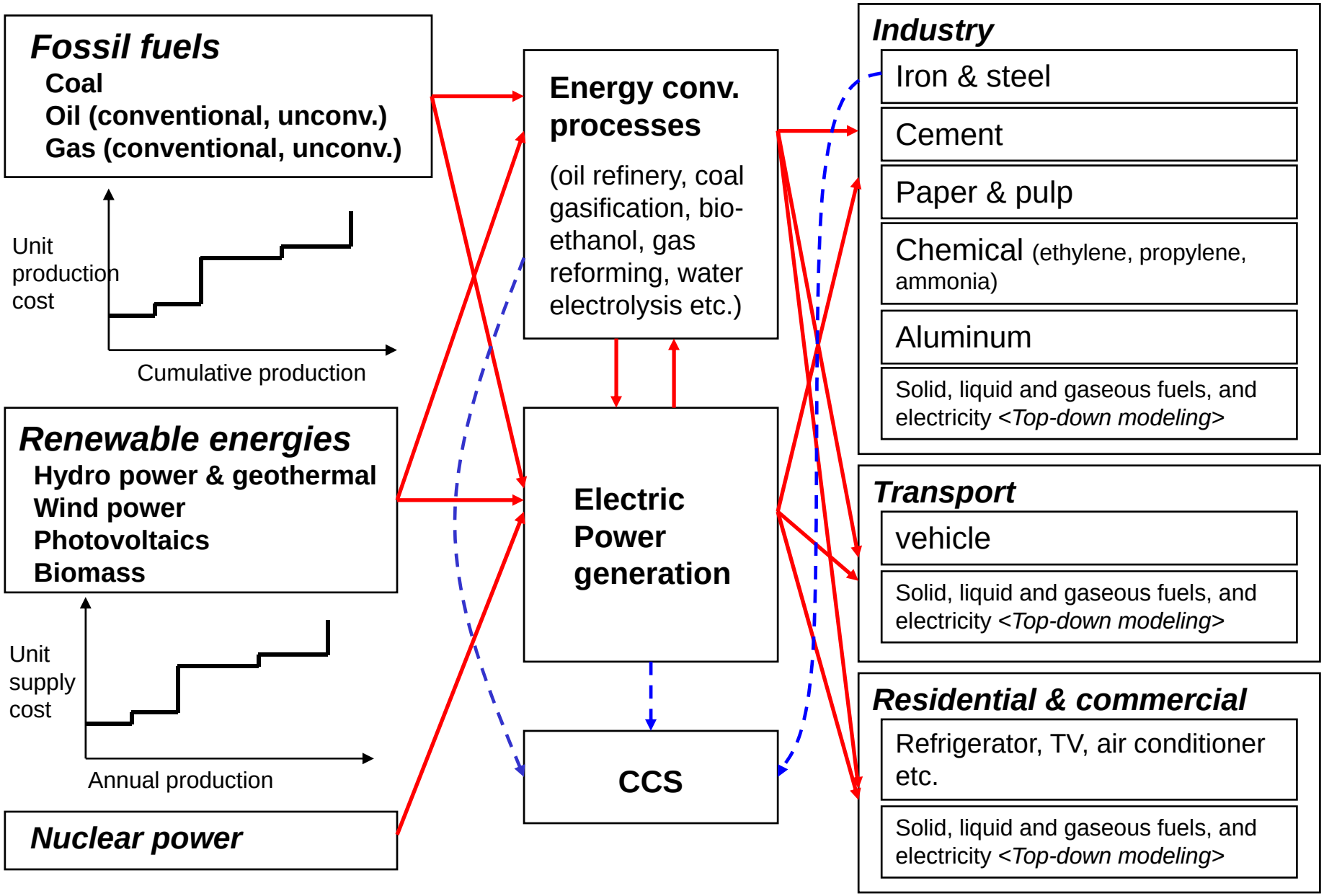
Appendix II:
Overview of DNE21+ model

Region divisions of DNE21+

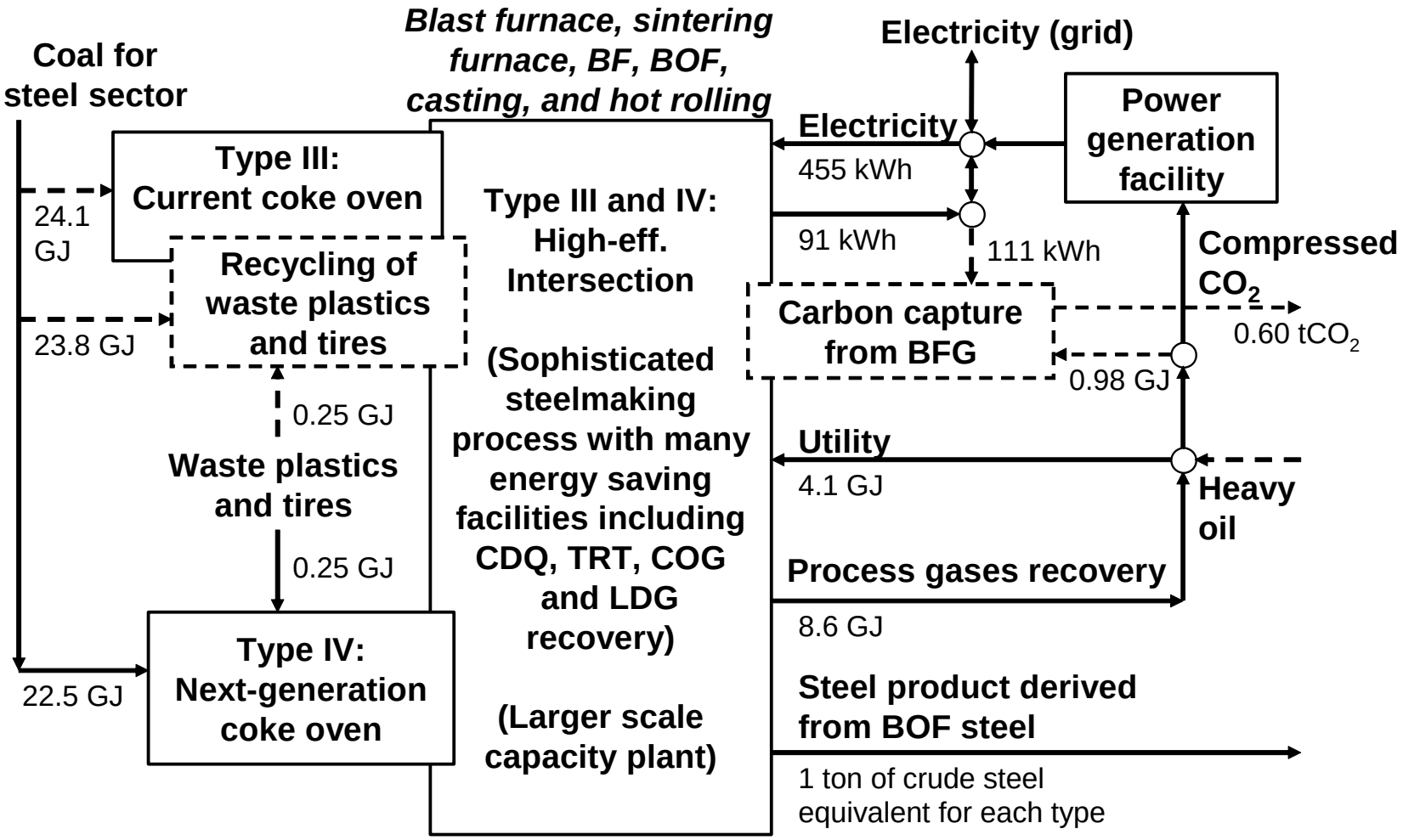


Technology Descriptions in DNE21+ (1/2)



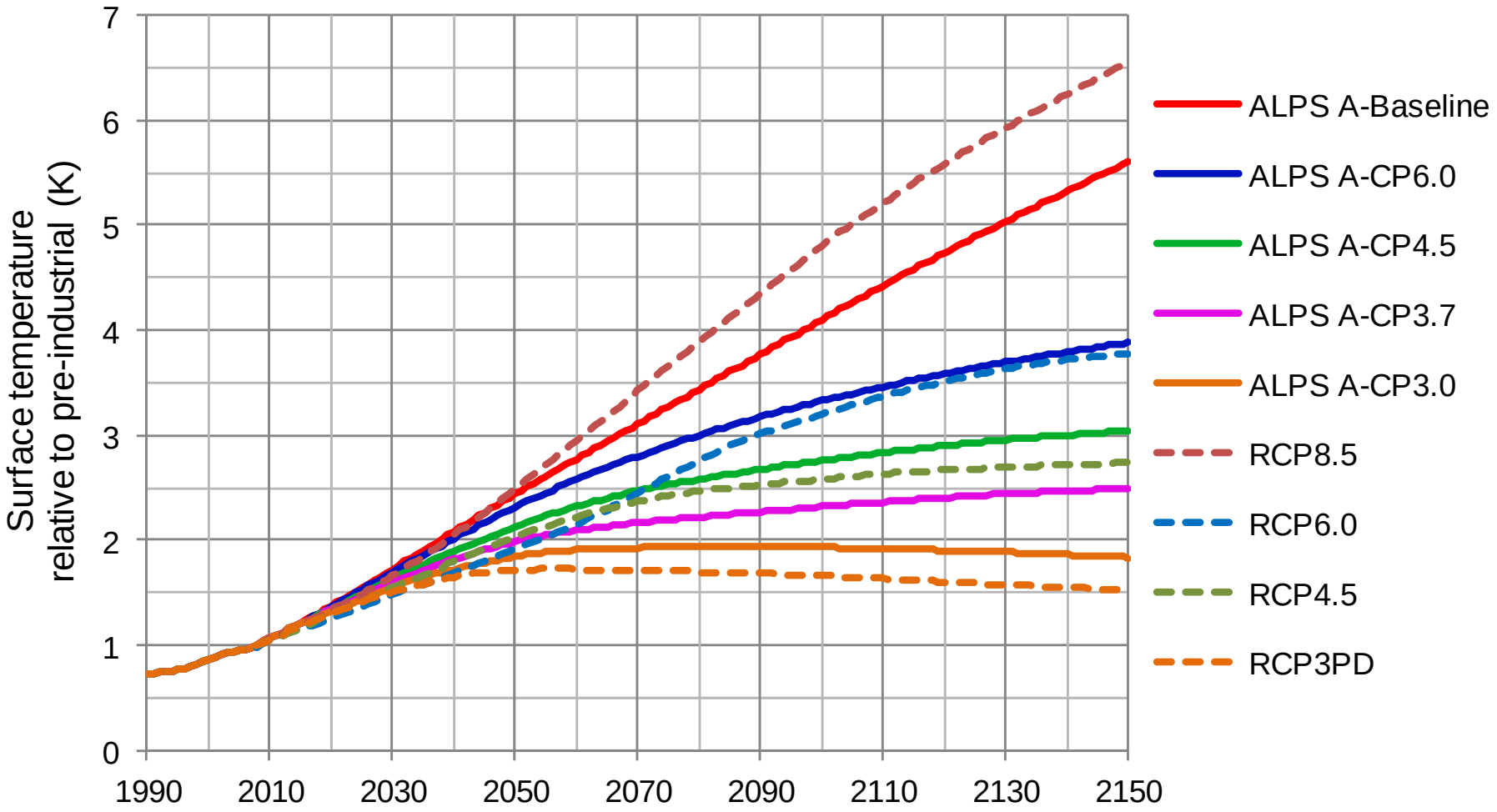
Technology Descriptions in DNE21+ (2/2)

–An Example for High Energy Efficiency Process in Iron & Steel Sector–



BF: blast furnace, BOF: basic oxygen furnace, CDQ: Coke dry quenching, TRT: top-pressure recovery turbine, COG: coke oven gas, LDG: oxygen furnace gas

Global Mean Temperature Rise

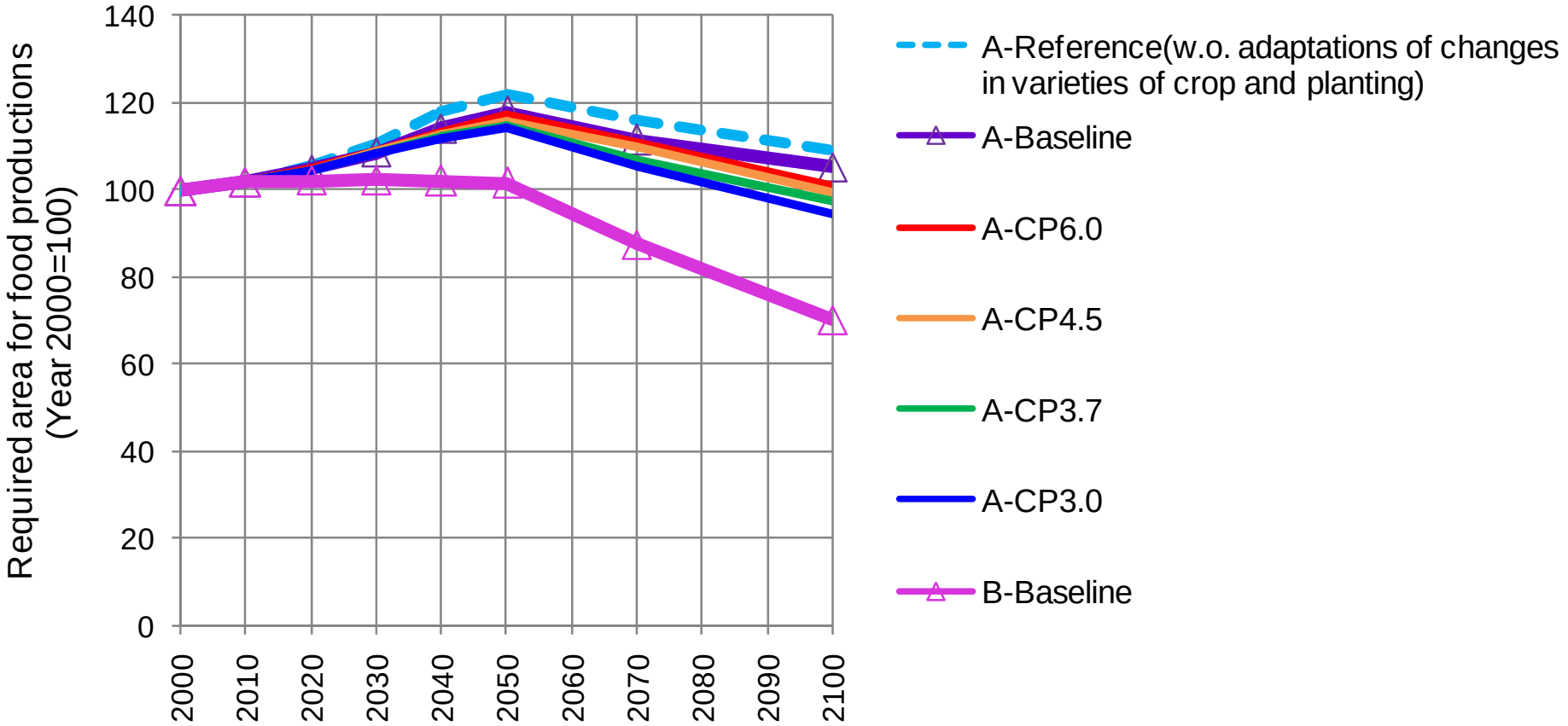


Note: Equilibrium climate sensitivity is assumed to be 3 °C, which is a ”most likely value” in IPCC AR4.

The maximum global mean temperature change relative to the pre-industrial level is about 2 °C (1.94 °C) for the ALPS CP3.0.

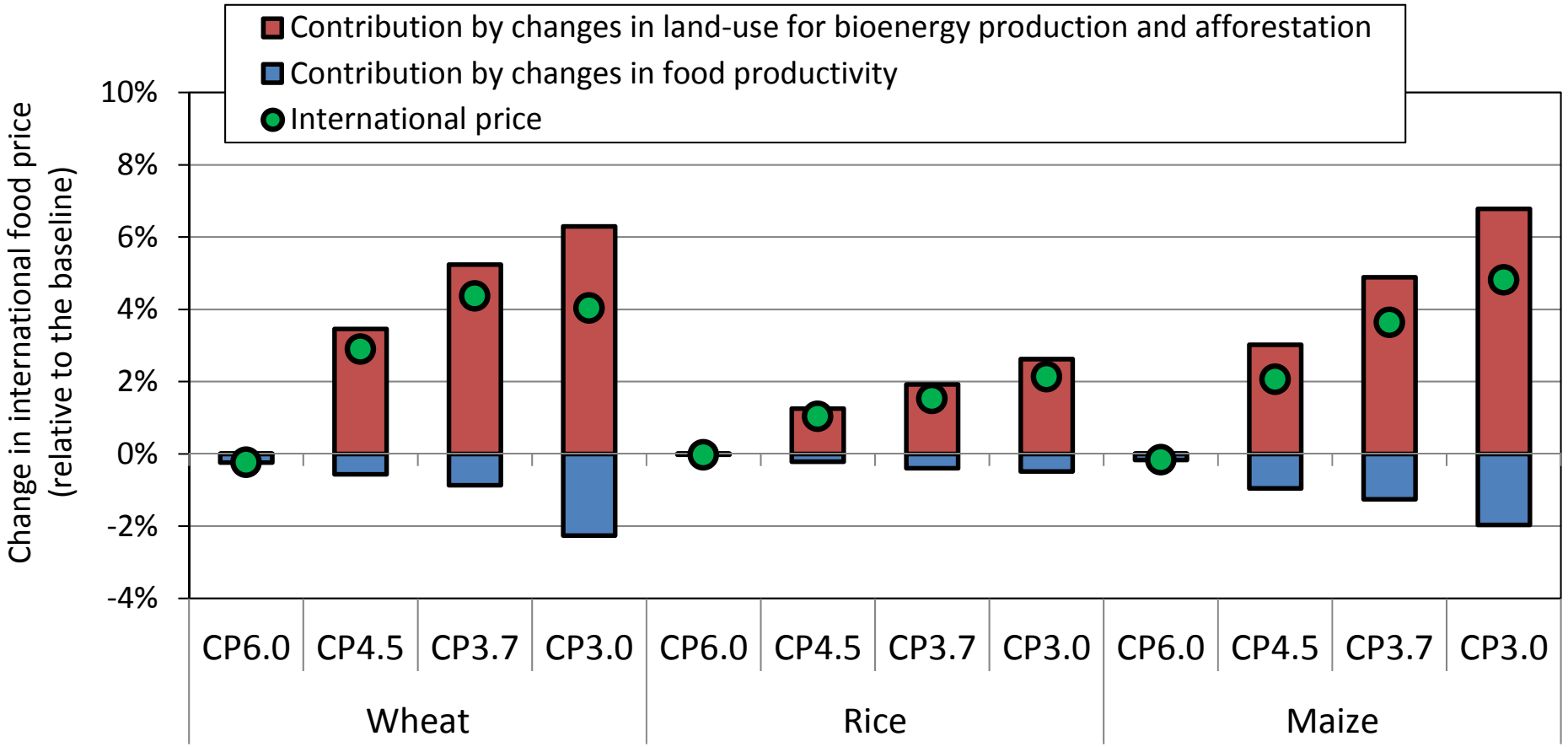
Agriculture Land Area

Required area for food productions to meet food demands



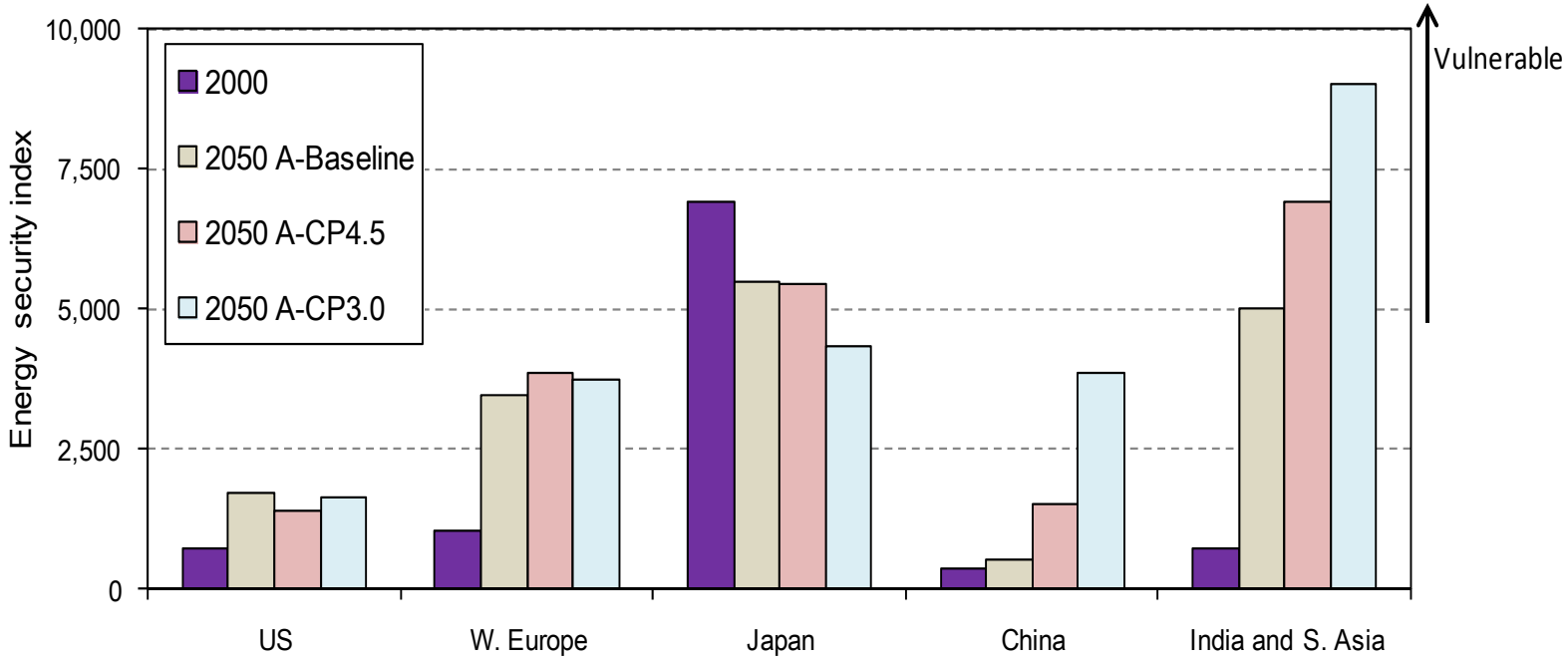
The additional required area for crop productions will be about 20% in 2050 under Scenario A-Baseline. The area in the case of climate stabilization at a low level will be smaller than that of the baseline. However, socioeconomic conditions, such as population, will have larger effects on the required area.

Food Price Change by Factor in 2050



The productivity of wheat, rice and maize will increase under most of the emission reduction scenarios compared with the productivity in the baseline, and the food prices will decrease in lower emission scenarios. On the other hand, large scale of bioenergy production and afforestation under emission reduction scenarios will increase food prices.

Assessment of Energy Security
– For Different levels of concentration –



$$ESI = \frac{c_{oil}}{TPES}\sum_i \left(r_i \cdot S_{i,oil}{}^2\right) + \frac{c_{gas}}{TPES}\sum_i \left(r_i \cdot S_{i,gas}{}^2\right)$$

Share of imported oil in TPES

Political risks of region i

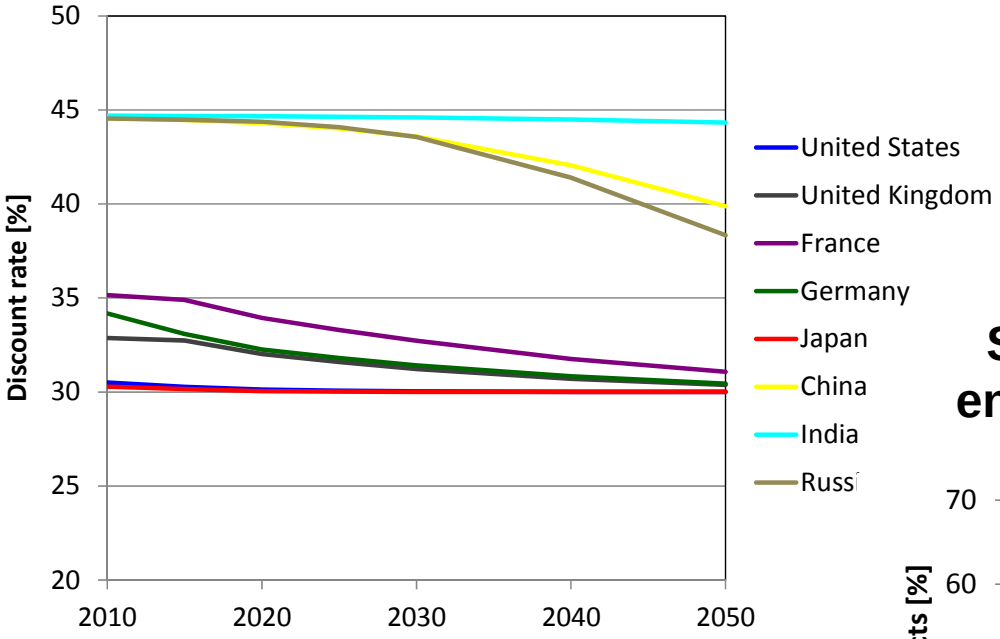
Dependence on region i

ESI : energy security index, TPES: total primary energy supply
Note: index based on IEA, 2007

While the energy security index of Japan decreases (less vulnerable) for CP3.0, that of China, India increases (more vulnerable) for deeper emission reductions due to increase in imported gas shares.

Assumed discount rate and share of environmental conscious purchasers in transport sector (tentative)

Discount rate in transport sector (road)



Share of purchaser preferring to environmental conscious products in small passenger car sales