IPCC WG3 Symposium

September 8, 2014

Emission Pathways, Mitigation Costs and the Economic Impacts

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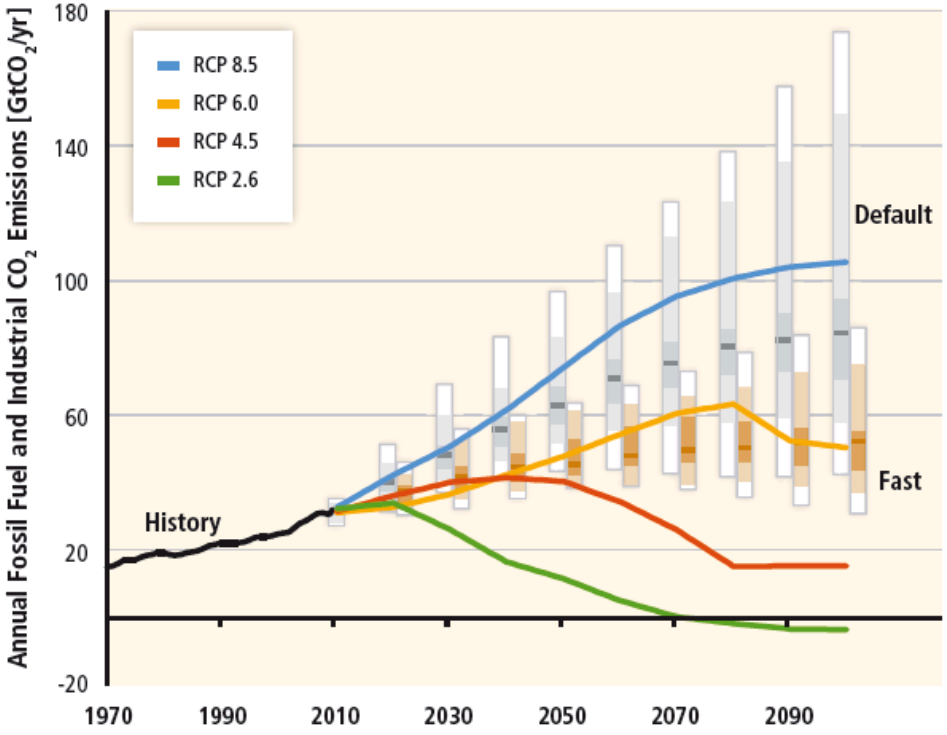
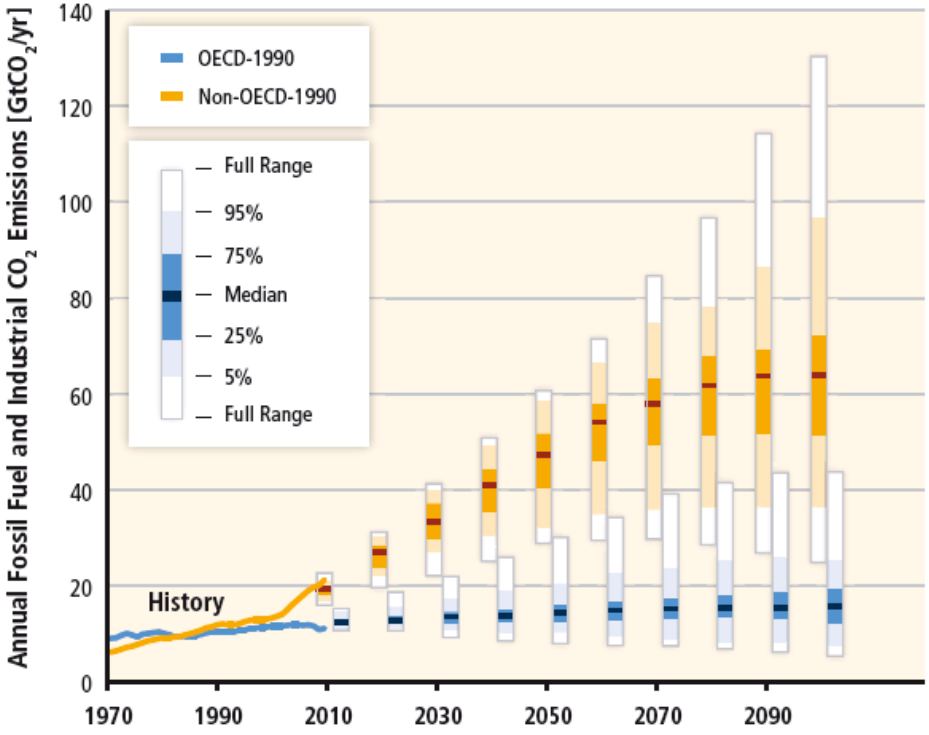
(LA of IPCC WGIII AR5, Chapter 6)

Long-term Emission Pathways

Baseline Emissions

Figure 6.4





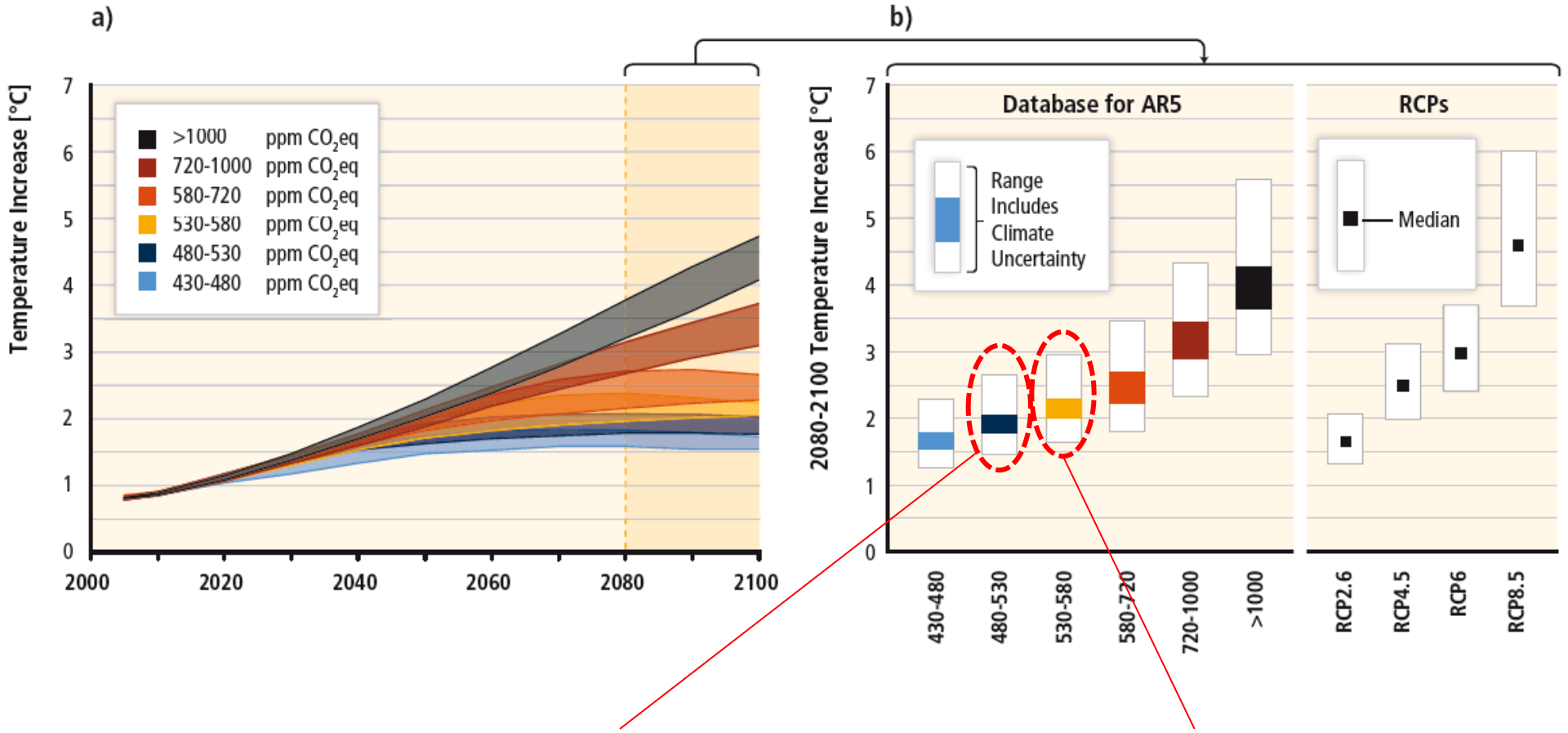
- The median estimate of baseline CO2 emissions is around 80 GtCO2 in 2100, of which is more than twice the current level, and smaller and larger than those in RCP6.0 and RCP8.5, respectively. (RCP: Representative Concentration Pathway)
- The emission of OECD1990 almost keeps the current level during the 21st century, but the emission of non-OECD1990 increases drastically.

Atmospheric GHG Concentration, Emission Reduction in 2050, and Expected Temperature Increase (based on AR5 Table SPM.1, Table 6.3)

Category by concentration in 2100 (ppm CO2eq)	Sub-category	RCPs	Global GHG emissions in 2050 (relative to 2010)	Temperature in 2100 (°C, relative to 1850-1900)	Probability of exceeding the temperature rise over 21st century (relative to 1850-1900)		
					1.5 °C	2.0 °C	3.0 °C
450 (430-480)	—	RCP2.6	-72–-41%	1.5–1.7°C (1.0–2.8)	49-86%	12-37%	1-3%
500 (480-530)	No exceedance of 530 ppm CO2eq		-57–-42%	1.7–1.9°C (1.2–2.9)	80-87%	32-40%	3-4%
	Exceedance of 530 ppm CO2eq		-55–-25%	1.8–2.0°C (1.2–3.3)	88-96%	39-61%	4-10%
550 (530-580)	No exceedance of 580 ppm CO2eq		-47–-19%	2.0–2.2°C (1.4–3.6)	93-95%	54-70%	8-13%
	Exceedance of 580 ppm CO2eq		-16–+7%	2.1–2.3°C (1.4–3.6)	95-99%	66-84%	8-19%
(580-650)	—	RCP4.5	-38–+24%	2.3–2.6°C (1.5–4.2)	96-100%	74-93%	14-35%
(650-720)	—		-11–+17%	2.6–2.9°C (1.8–4.5)	99-100%	88-95%	26-43%
(720-1000)	—	RCP6.0	+18–+54%	3.1–3.7°C (2.1–5.8)	100-100%	97-100%	55-83%
>1000	—	RCP8.5	+52–+95%	4.1–4.8°C (2.8–7.8)	100-100%	100-100%	92-98%

Global Mean Temperature Change of Different Scenario Categories

Figure 6.13

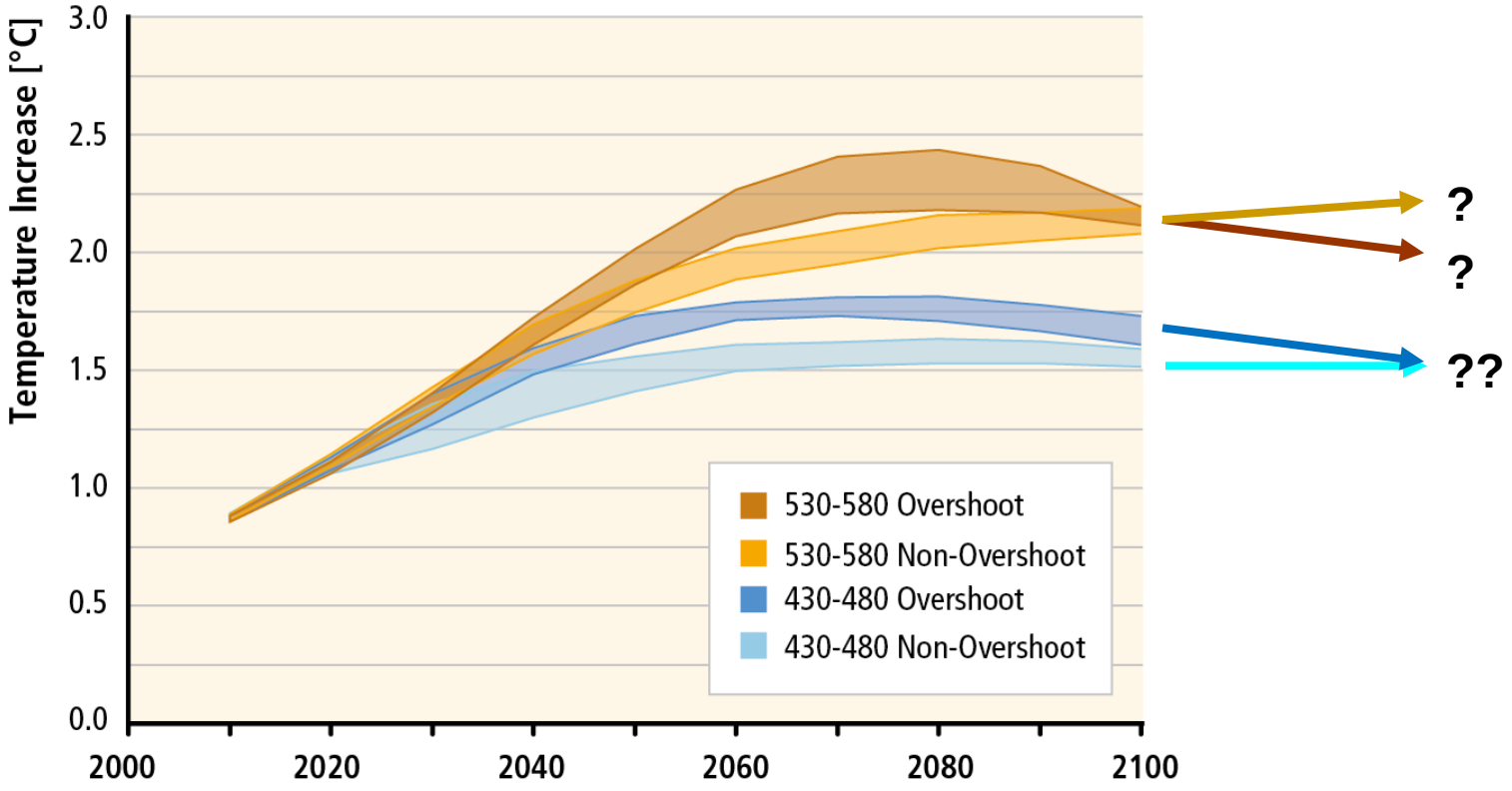


Not only 430-480 ppm CO2eq, but also 480-530 ppm CO2eq scenarios also expect 2 °C increase with the chance larger than 50%.

As climate sensitivity has a large uncertainty range, there is a considerable chance to meet below +2 °C even under 530-580 ppm CO2eq scenarios.

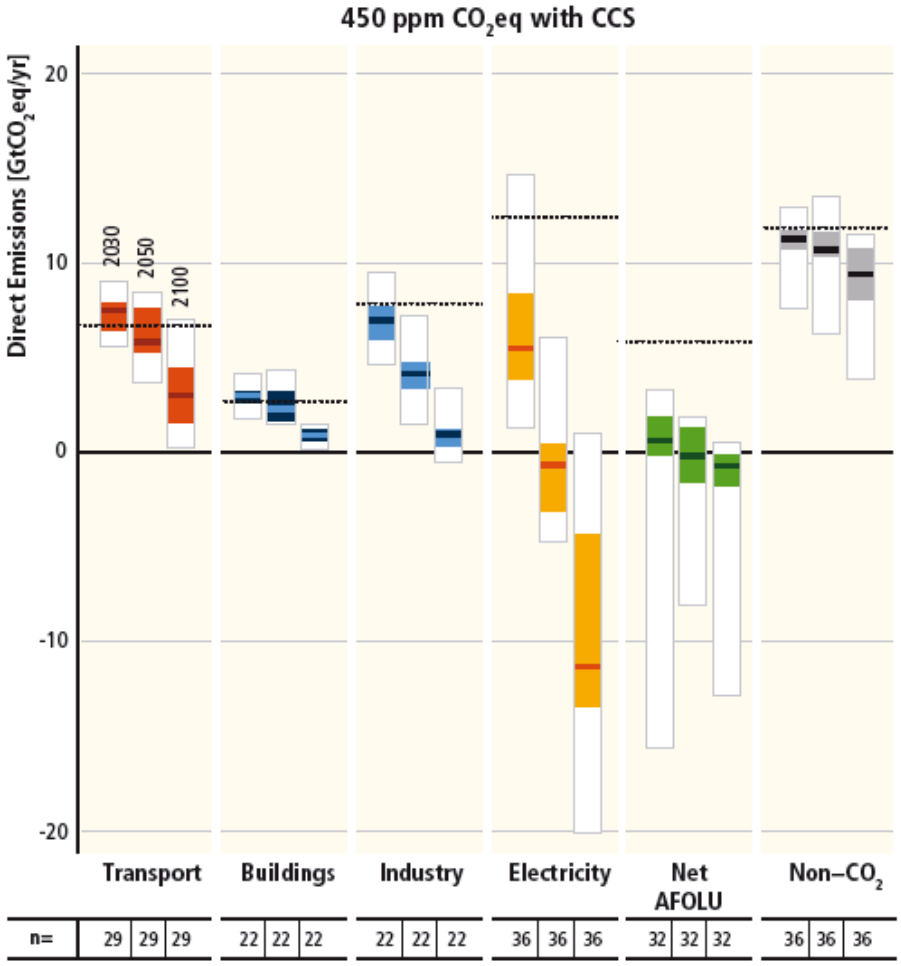
Scenarios with Overshoot of Temperature

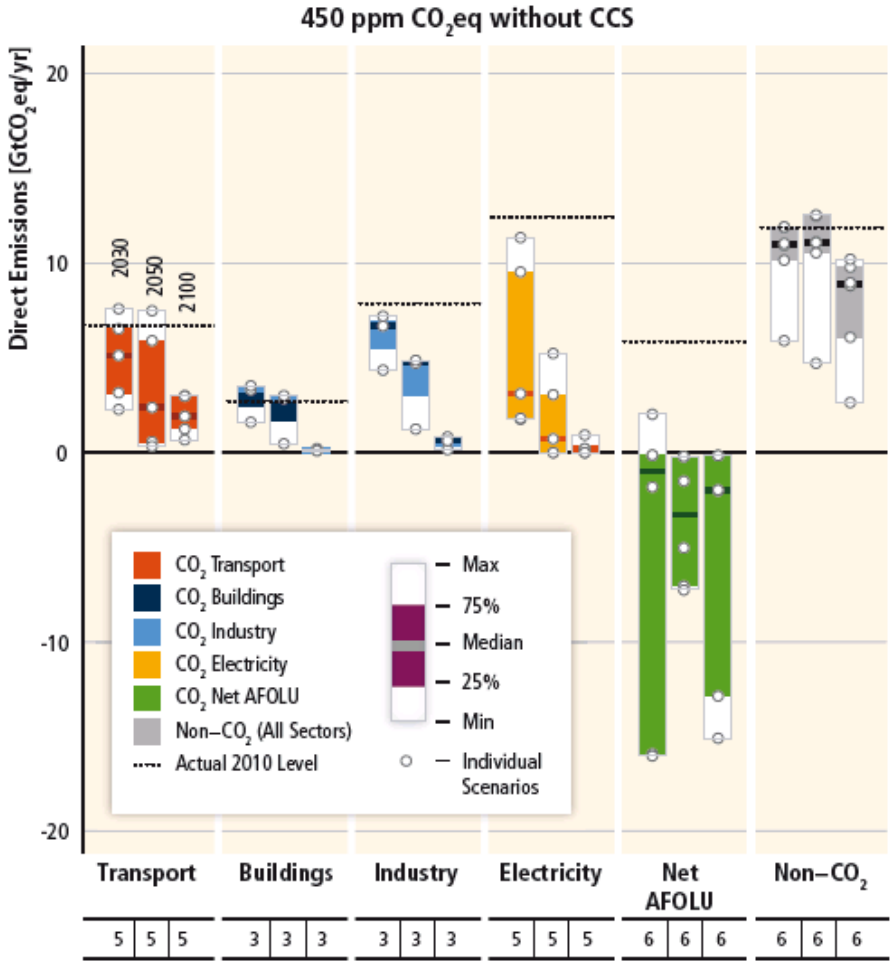
Figure 6.13



- Scenarios with overshoot of atmospheric CO2 concentration and of temperature were assessed in AR5 as well as concentration stabilization scenarios particularly for tight temperature increase scenarios.
- High increase of actual global emissions after 2000 and “political” deep emission reduction targets such as +2 °C target, combined together, induced to generate such overshoot scenarios to solve both two inconsistent conditions.

Emissions by Sector for 430-480 ppm





- Negative emissions in electricity are required for 450 (430-530) ppm CO2eq scenarios after 2050 by large use of BECCS.
- When CCS including BECCS is unavailable, large scale of afforestation is required.
- In both cases, the impacts on food prices through land conflict cause concern.

Global GHG Emissions in 2050 – Comparison with AR4 and AR5 –

Required emission reduction ratio in 2050 for below 2 °C relative to preindustrial level

	Forth Assessment Report (AR4) 450 ppm CO2eq stabilization scenarios (best estimate of climate sensitivity)		Fifth Assessment Report (AR5) Only the scenarios of 450 ppm CO2eq in 2100		Fifth Assessment Report (AR5) About 50% for expecting below 2 °C (including 500 ppm CO2eq scenarios)
Relative to 2000	-50% to -85%	→	-26 to -65%	→	**-6% to -65%**
Relative to 2010	-60% to -88%	→	-41% to -72%	→	**-25% to -72%**

- According to the assessments of AR5, the required level of global GHG emission reduction in 2050 for the 2 °C goal should be considered to be more flexible than the AR4 implication. For example, the levels are between -26% and -6% relative to 2000.
- They correspond to the level of -41 to -25% relative to 2010.

Lessons from the Long-term Scenarios of AR5

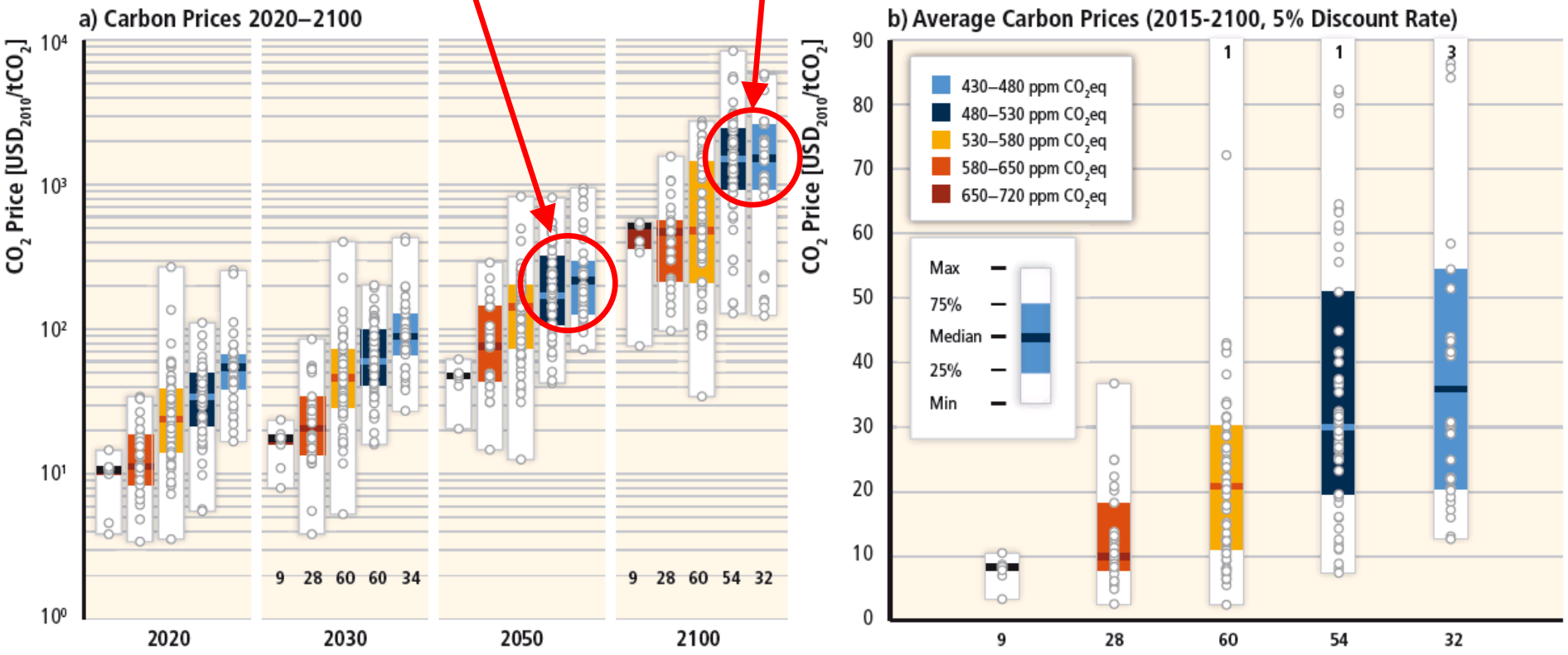
- Global GHG emissions in baseline will continue to increase during this century, and the deep emission reductions are surely required.
- A lot of emission scenarios (over 1000 scenarios) were gathered from several scientific communities in the world for the AR5.
- According to the gathered scenarios, there are considerable flexibilities in the long-term pathways to meet the 2°C goal, such as overshoots of atmospheric GHG concentration and of temperature change, probabilities below the target level to be achieved (e.g., >50% or >66%).
- Consequently, the required global GHG emission reductions by 2050 have wider ranges than those provided in the AR4.

Mitigation Costs and the Economic Impacts

Marginal and Average Abatement Costs

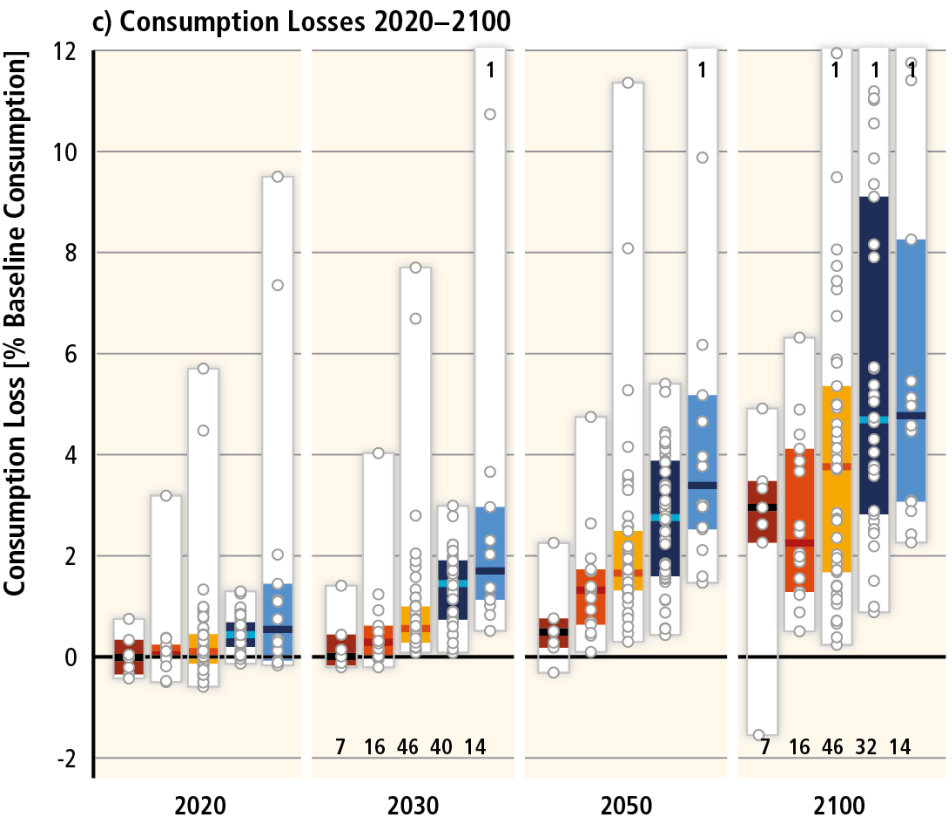
430-530 ppm CO2eq

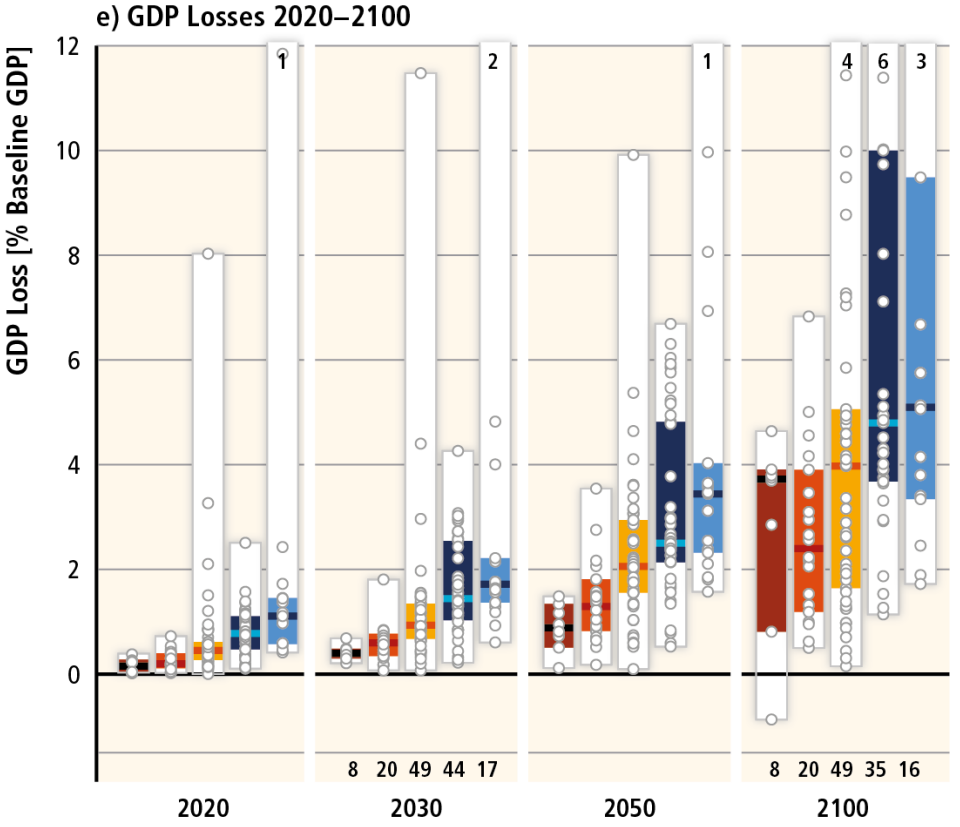
Around 100-300$/tCO2 **Around 1000-3000$/tCO2**



- The global CO2 marginal abatement costs (Carbon prices) for 430-530 ppm CO2eq in 2050 and 2100 are about 100−300 $/tCO2 (25-75 percentile) and about 1000−3000 $/tCO2, respectively.
- It will be very challenging to achieve such deep levels of emission reductions. Carbon pricing policies particularly explicit carbon pricing will not work for such high prices.

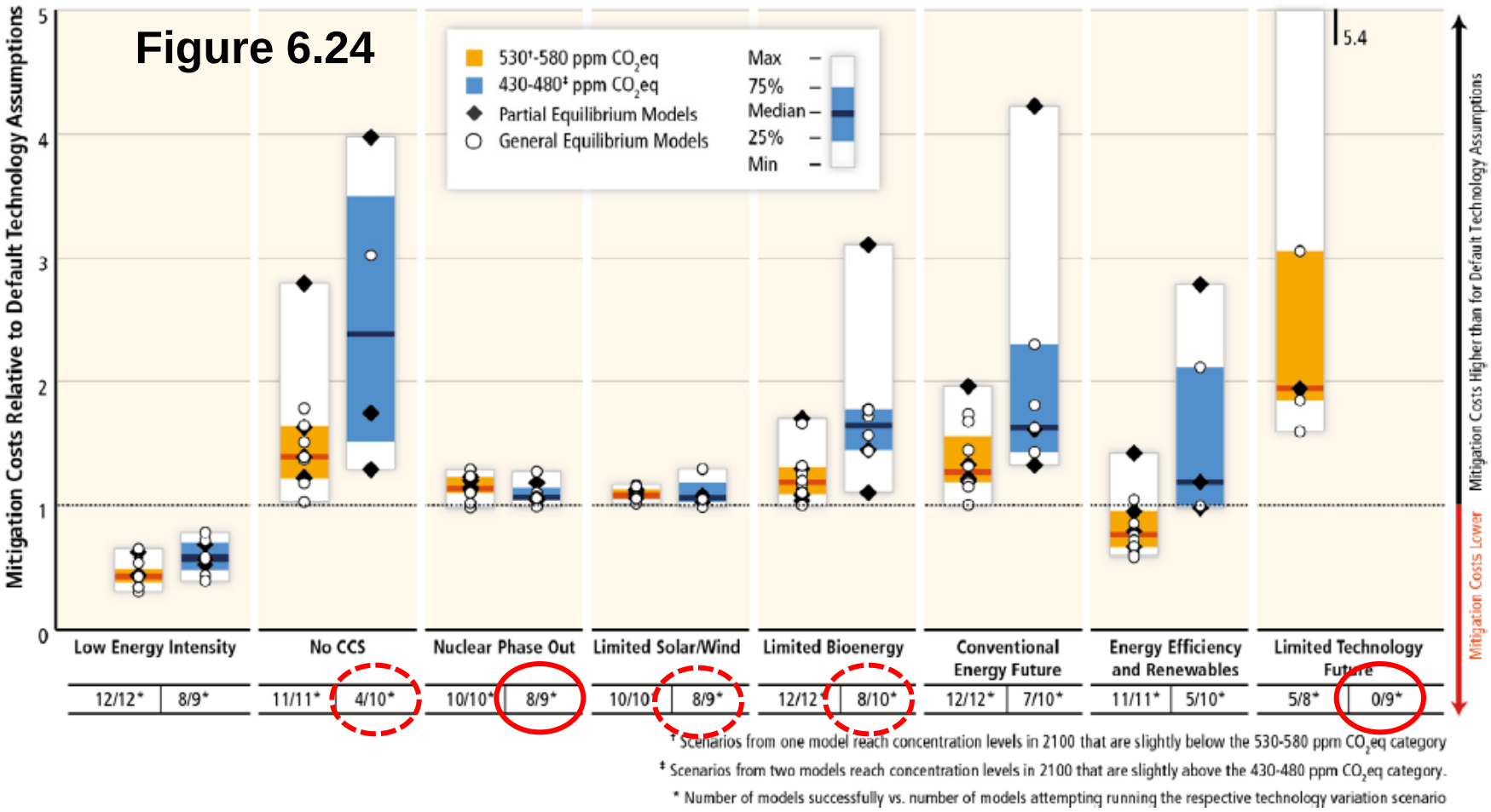
Consumption and GDP Losses





- GDP loss is about 4-10% (median: about 5%) of baseline GDP for 430-530 ppm in 2100.
- We should recognize that about 5% of GDP is not small by any means. The GDP of Africa in 2010 is about 2.4% of the global GDP. According to the outlook by RITE, the GDP of Africa in 2050 is still about 5% of the global GDP.

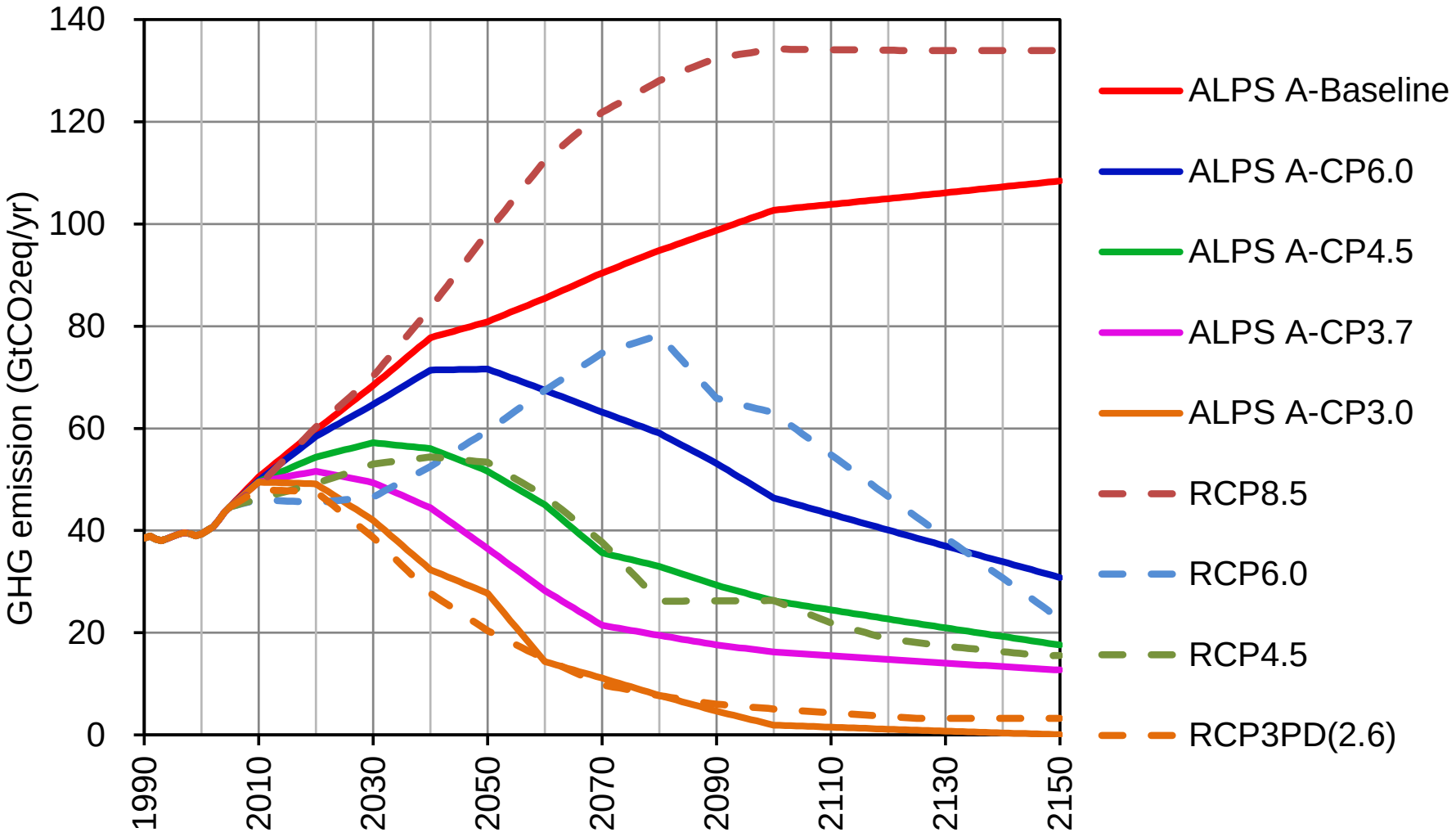
Cost Increase in the Scenarios with Limited Availability of Technologies



- Some of the models estimated that it is impossible to achieve the GHG concentration at 450 ppm CO2eq in 2100 when one of the key technologies are unavailable.
- The cost increase in the case without CCS is estimated to be about +29 to +297% (median: +138%) by a limited number of models which had the feasible solutions. The cost increases in the cases of nuclear phase-out and limited solar/wind are about +7% and +6%, respectively (for the median).

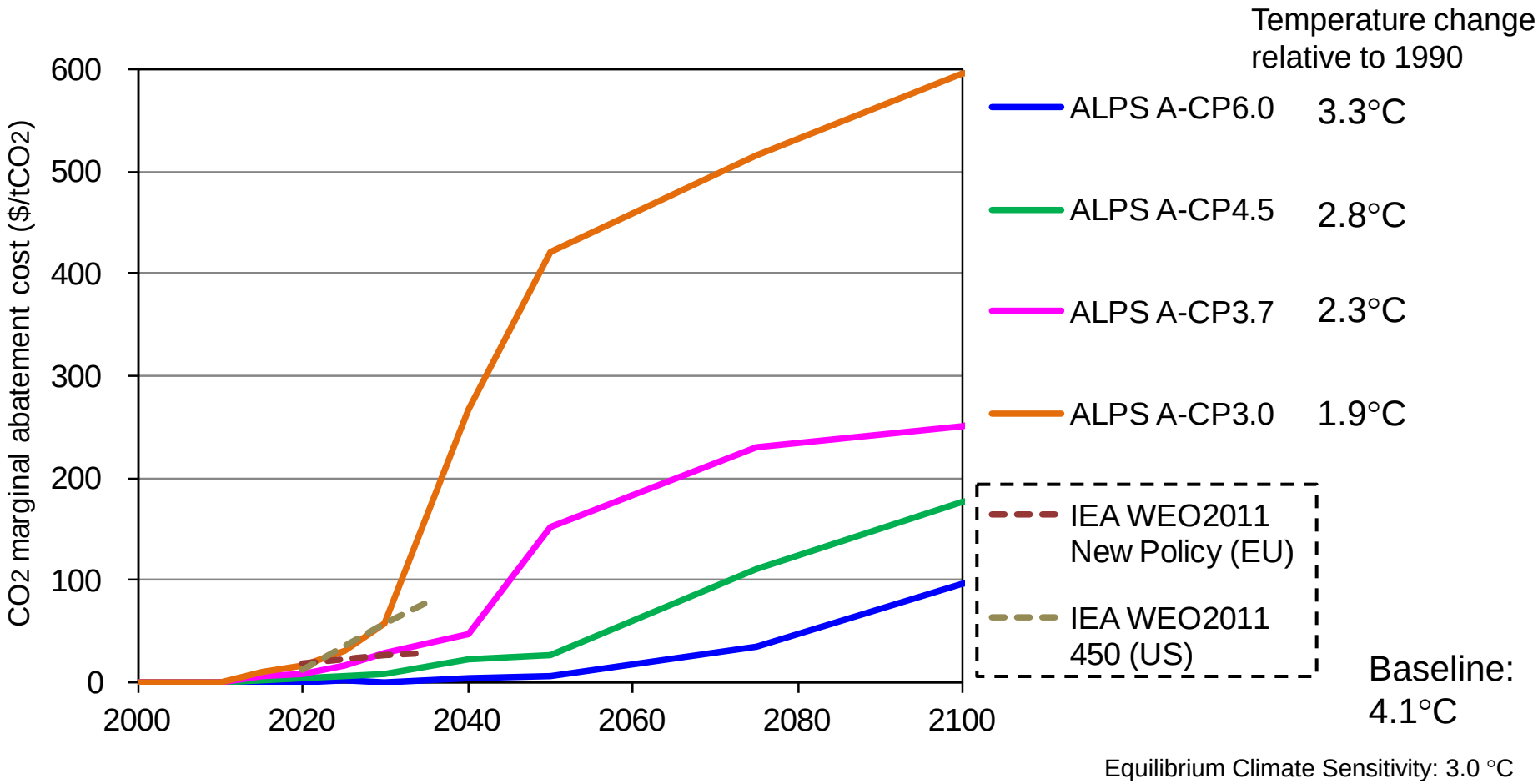
For Sustainable Measures toward Deep Emission Cuts
(Innovative Technologies Required)

RITE ALPS GHG Emission Scenarios



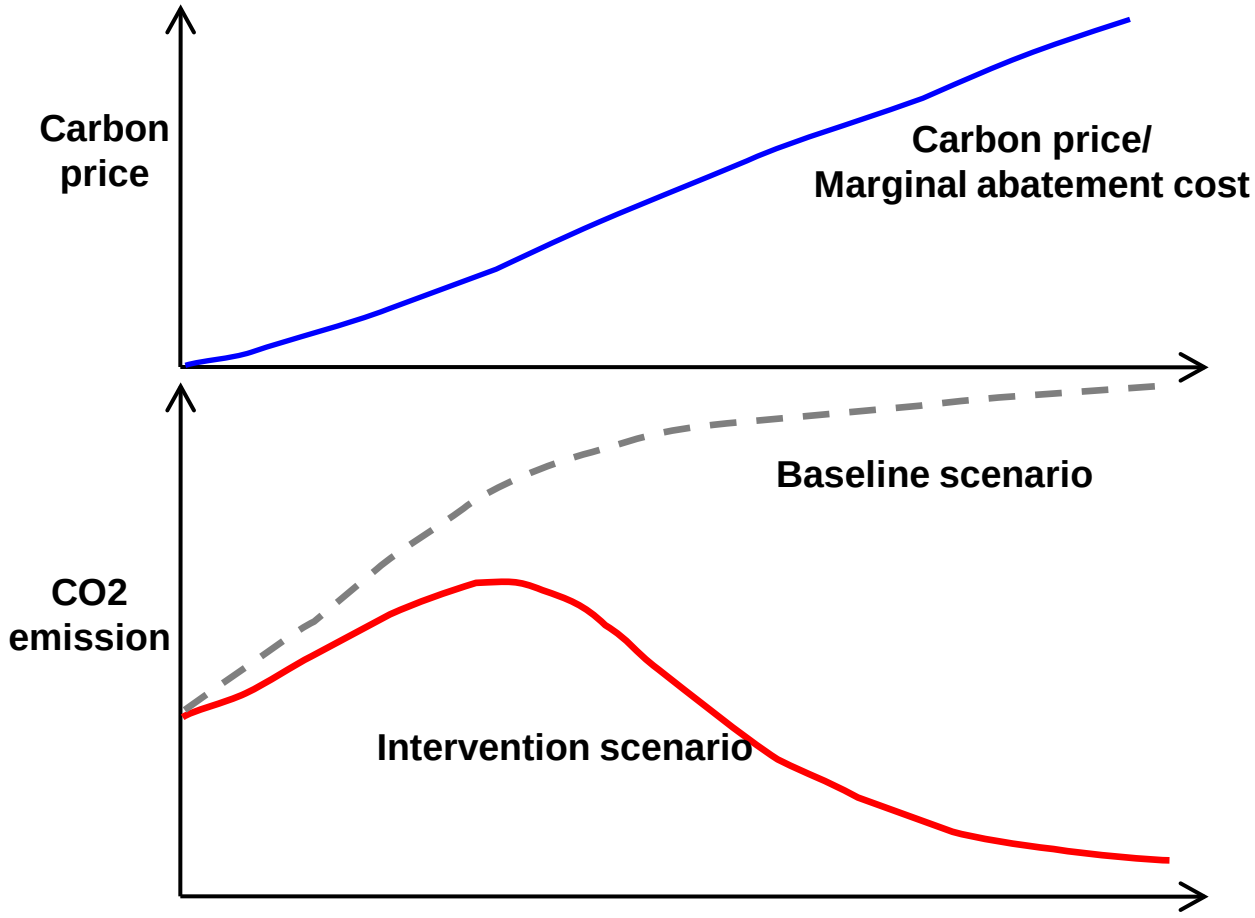
Note: CO_2 emissions including those from industrial processes and LULUCF
RCP: Representative Concentration Pathway
ALPS: ALternative Pathways toward Sustainable development and climate stabilization

CO_2 Marginal Abatement Cost for Different Stabilization Levels



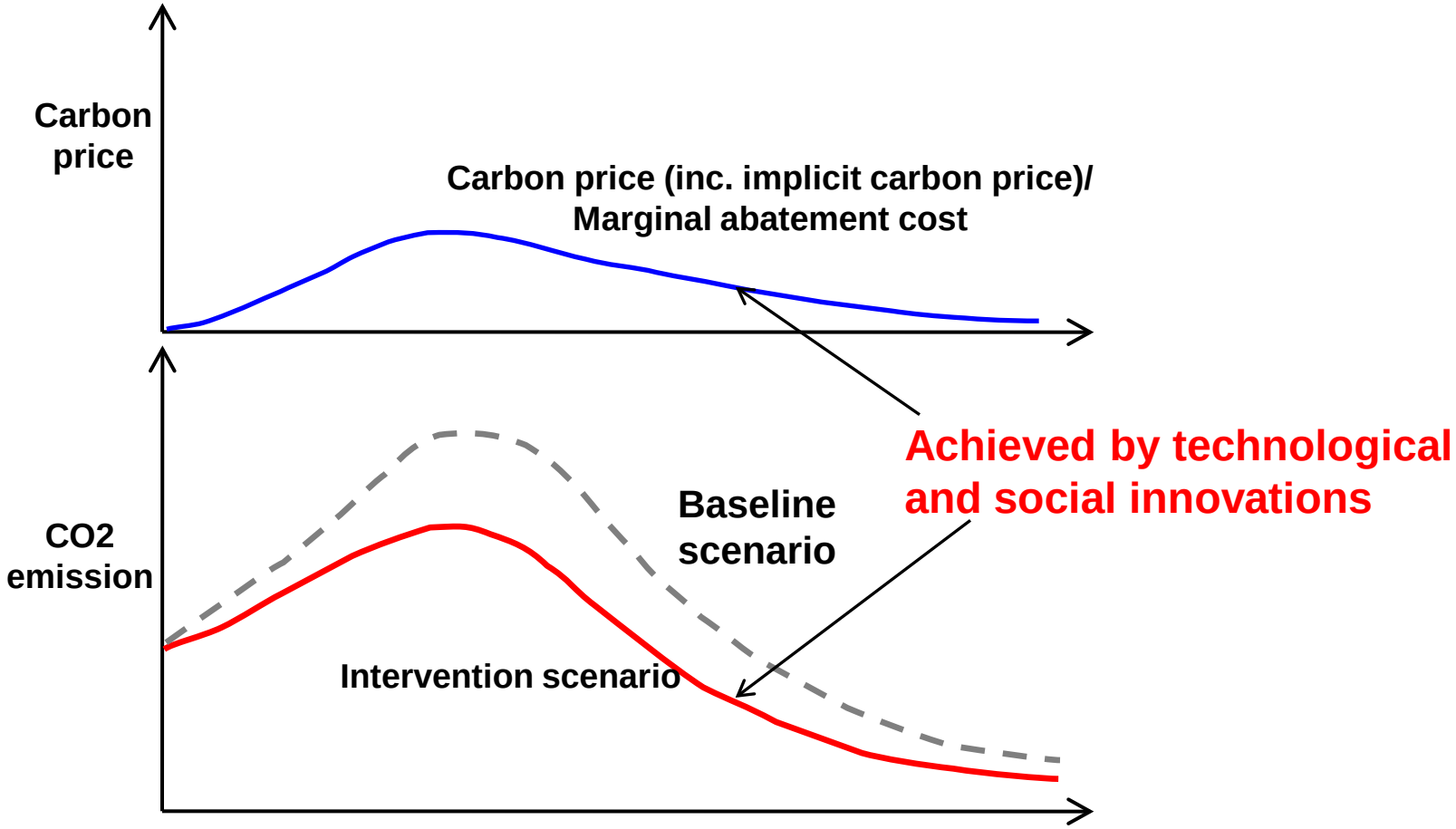
High marginal abatement costs are estimated after 2040 particularly for the 450 ppm CO_2eq. (CP3.0) scenario, like the result of the AR5, even if all the countries make the coordinated efforts (uniform marginal abatement cost) and the least cost mitigation measures are adopted.

Image of Standard Scenarios for Deep Cuts



This situations cannot be expected in a real world. Particularly explicit high carbon prices (e.g., over 100$/tCO2) in real price are unacceptable.

Possible Deep Cuts Scenario in a Real World



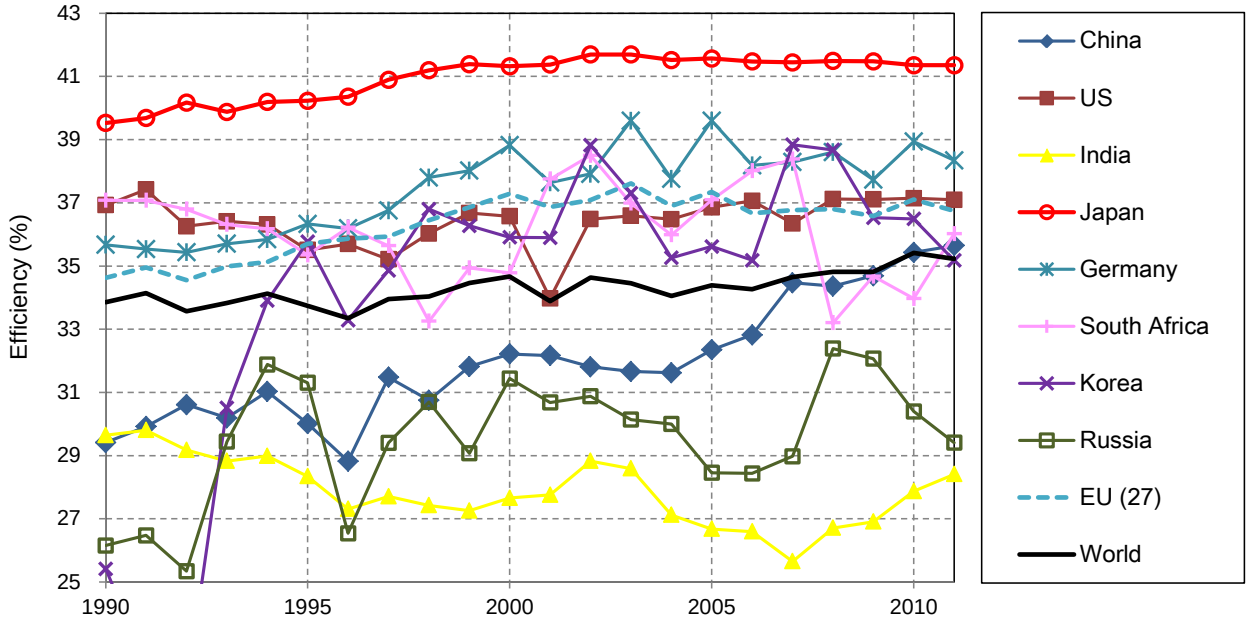
Mitigation measures avoiding high explicit carbon prices and technological and social innovations inducing low carbon prices are key for deep emission cuts.

For Sustainable Measures from the Viewpoint of Equitable Mitigation Costs across Regions/Countries

Mitigation Costs across Countries

- The mitigation costs summarized in the AR5 which were shown in the previous slides were estimated under basically the assumption of the least cost measures, that means the equal marginal abatement costs across countries were assumed.
- When the emission reduction measures with different marginal abatement costs across countries are implemented, the mitigation costs will be larger than those shown in AR5.
- Equitable efforts across countries will be required for achieving deep emission reductions with smaller mitigation costs in the world.

Energy efficiency comparison for major energy-intensive sectors

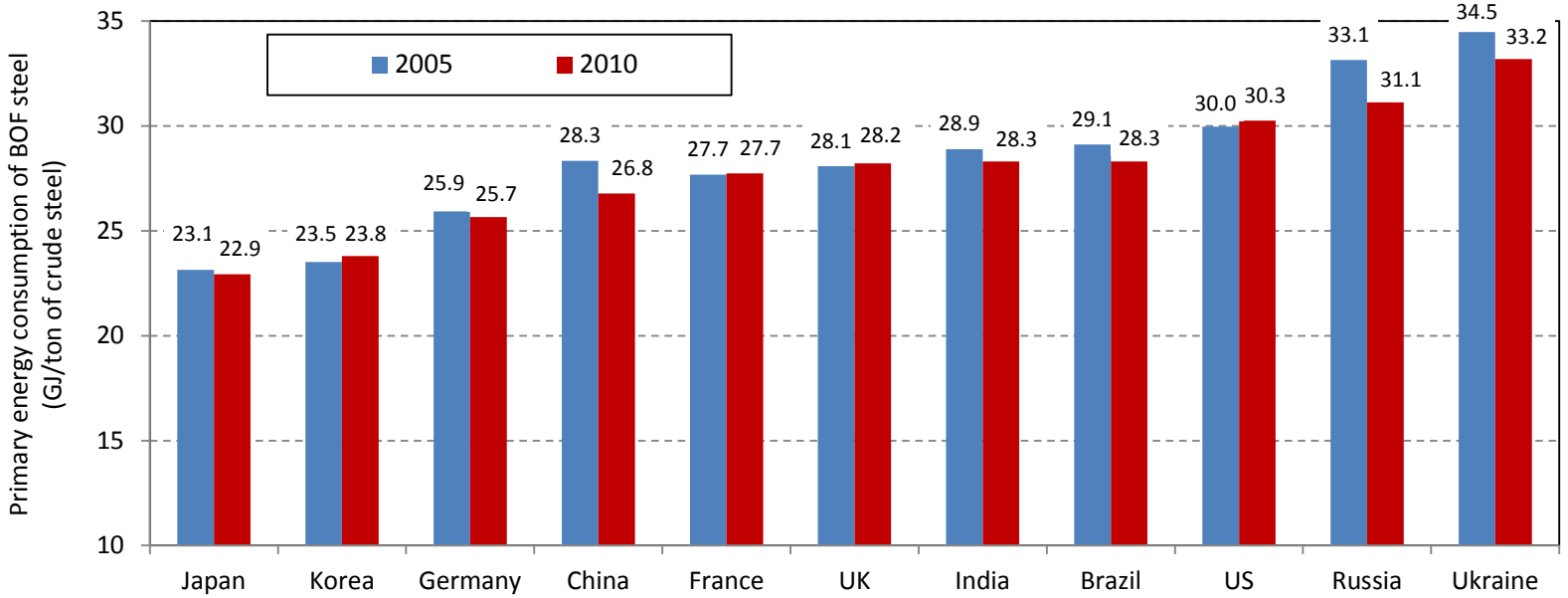


Coal power

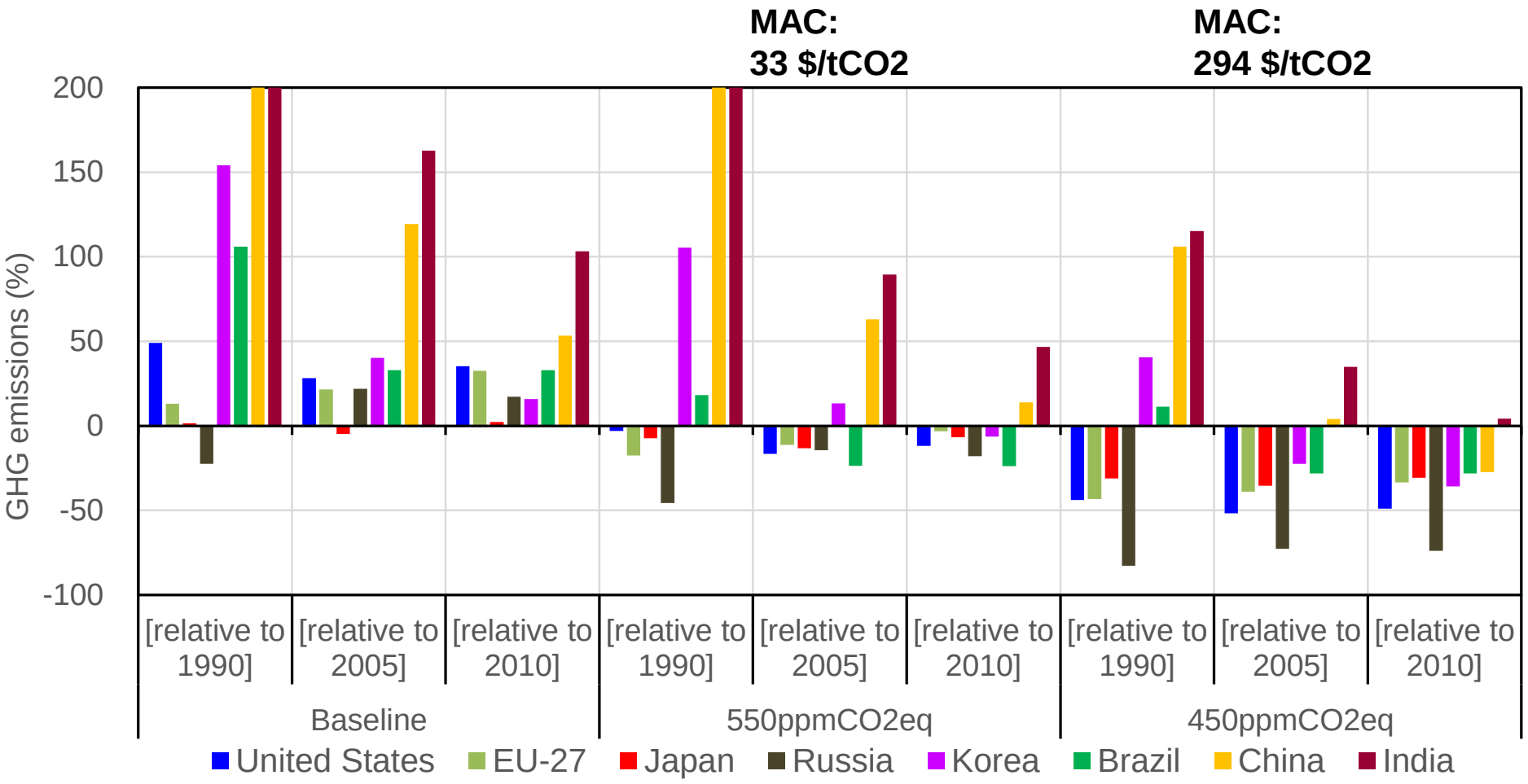
Source) RITE, 2014
based on IEA, 2013

Iron & steel (BOF steel)

Source) Oda et al. 2012; RITE, 2012



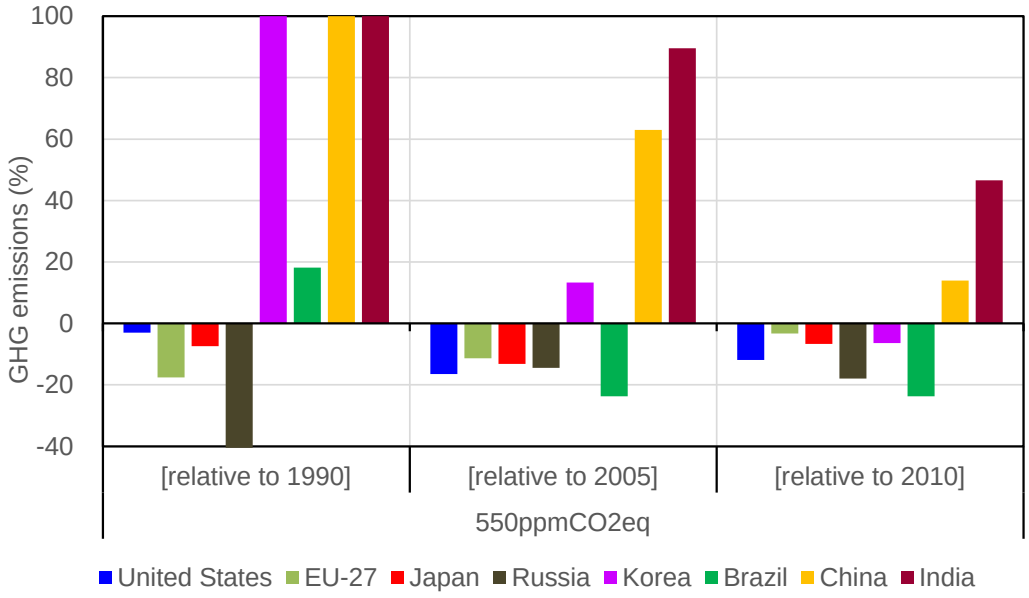
Emission Reduction Levels for Major Countries in 2030 for Meeting the Least Cost (1/2)



Source: RITE DNE21+ for the EMF27 study

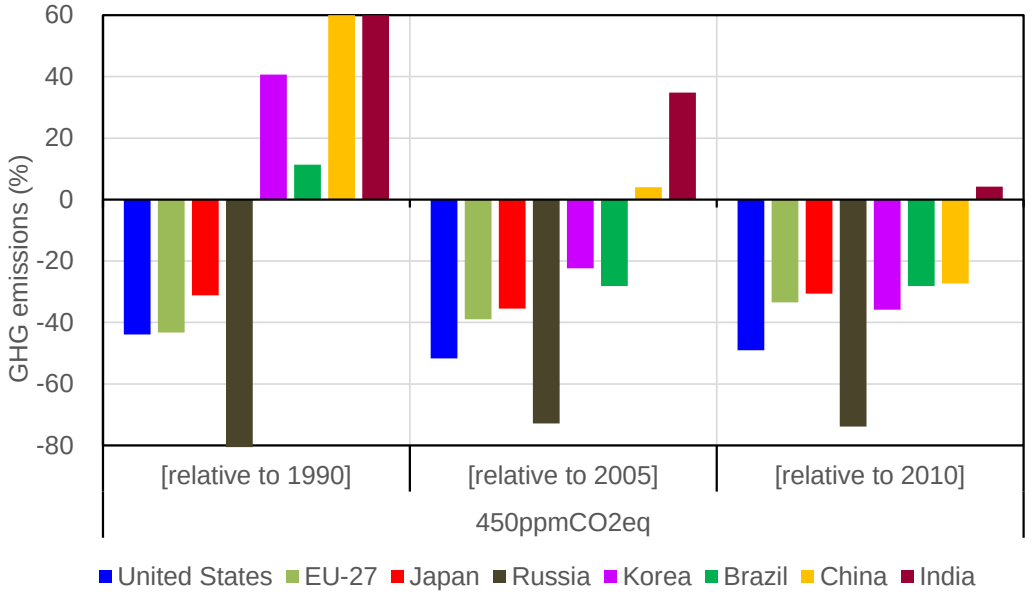
There are greatly different levels of emission reductions across countries for the least cost mitigation measures.

Emission Reduction Levels for Major Countries in 2030 for Meeting the Least Cost (2/2)



550 ppm CO2eq
MAC: 33 $/tCO2

450 ppm CO2eq
MAC: 294 $/tCO2



Source: RITE DNE21+ for the EMF27 study

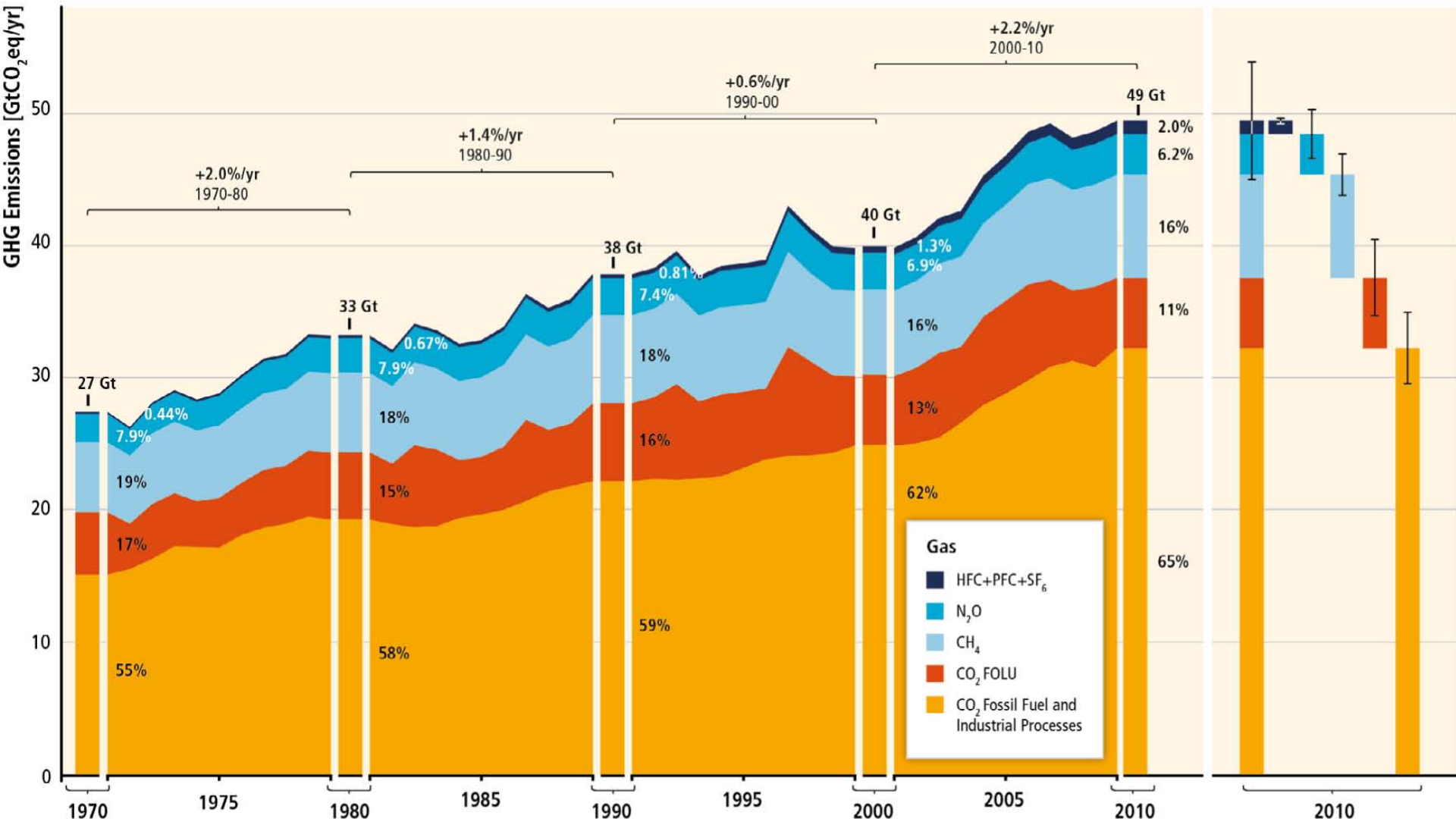
Note: The assumption that nuclear power can be deployed and operated also in Japan according to an international outlook for nuclear power are adopted.

Conclusion

- Climate change is a big issue and should be seriously tackled.
- IPCC AR5 greatly improved from the AR4 in several fields. Assessments of emission pathways were also improved by several international collaboration projects etc.
- A certain range of emission levels and of emission pathways exist even for meeting a certain target of temperature level, e.g., 2 °C goal, with different probabilities of achievement, overshoot/non-overshoot etc.
- Mitigation costs are large for deep emission reduction scenarios.
- Wide deployments of all the low-carbon technologies and the large contributions of all countries to emission reductions with equitable efforts will be necessary for deep emission reductions.
- In addition, innovative technologies will be required for deep emission reductions such as 450 ppm CO2eq. to be achieved in the real world.

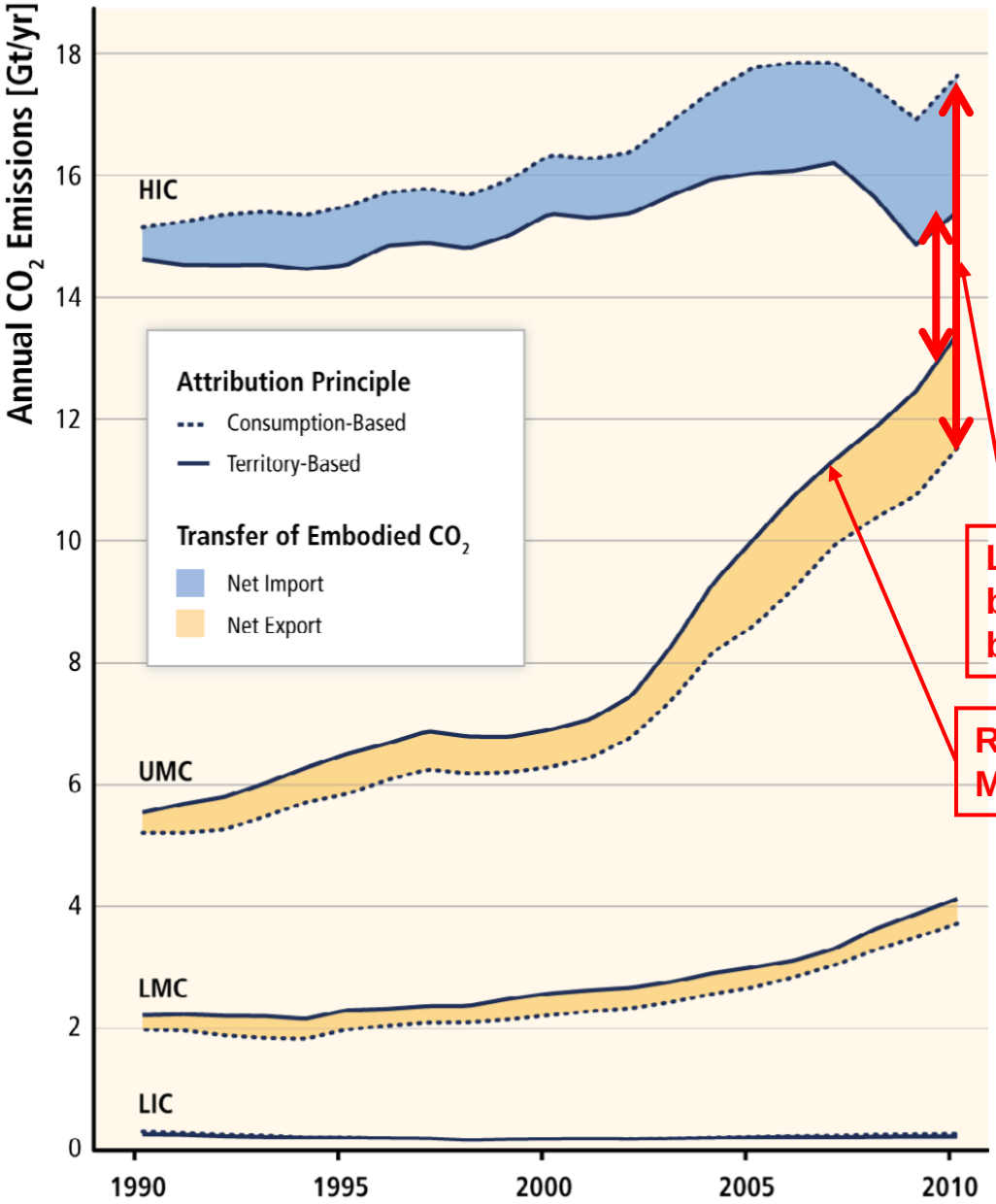
Appendix

Historical Global GHG Emissions Profiles



Despite several climate policies including Kyoto Protocol, the speed of global GHG emission increase between 2000 and 2010 rather higher than that before 2000.

Historical CO_2 Emissions for Country Income Groups



High Income Countries
($12,616 and more)

Upper Middle Income Countries
($4,086 to $12,615)
(China, Brazil, Iran, Malaysia, South Africa etc.)

Larger differences in emissions still exist in between HIC and UMC when consumption-based measures are adopted.

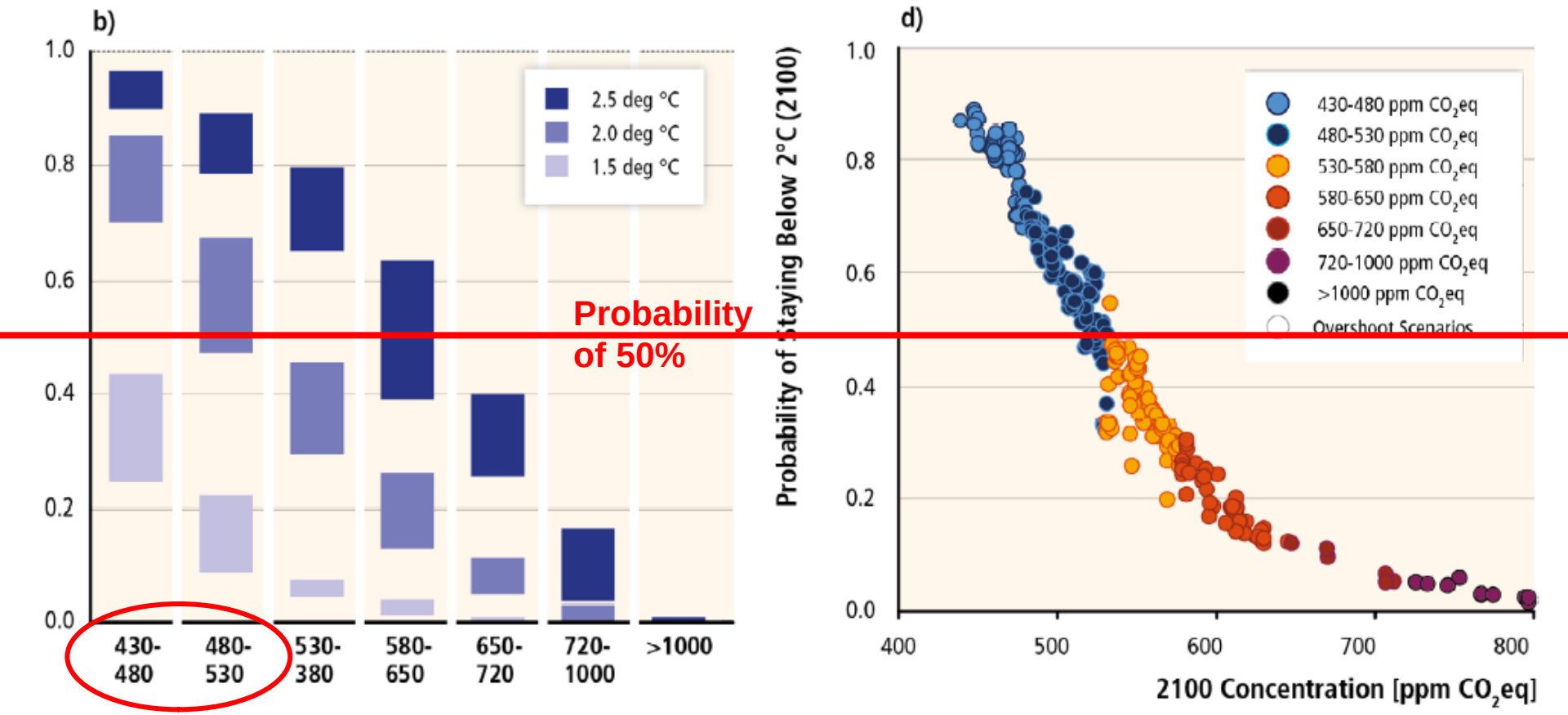
Rapid increase in emissions in the Upper Middle Income Countries

Lower Middle Income Countries
($1,036 to $4,085)
(India, Indonesia, Philippines, Egypt etc.)

Low Income Countries
($1,035 and less)

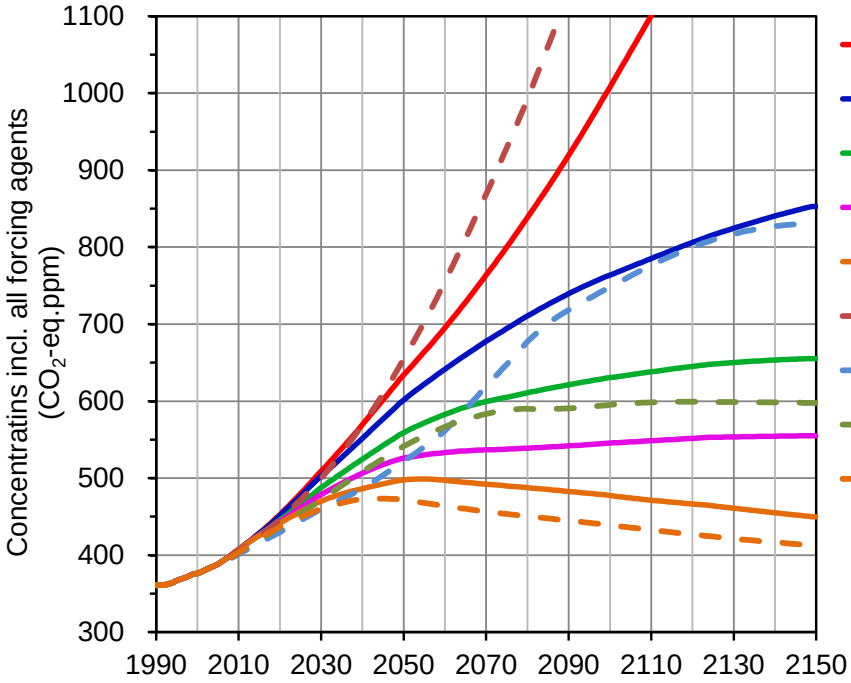
Relationship between CO2 Concentration Category and Probability Achieving the Temperature Level

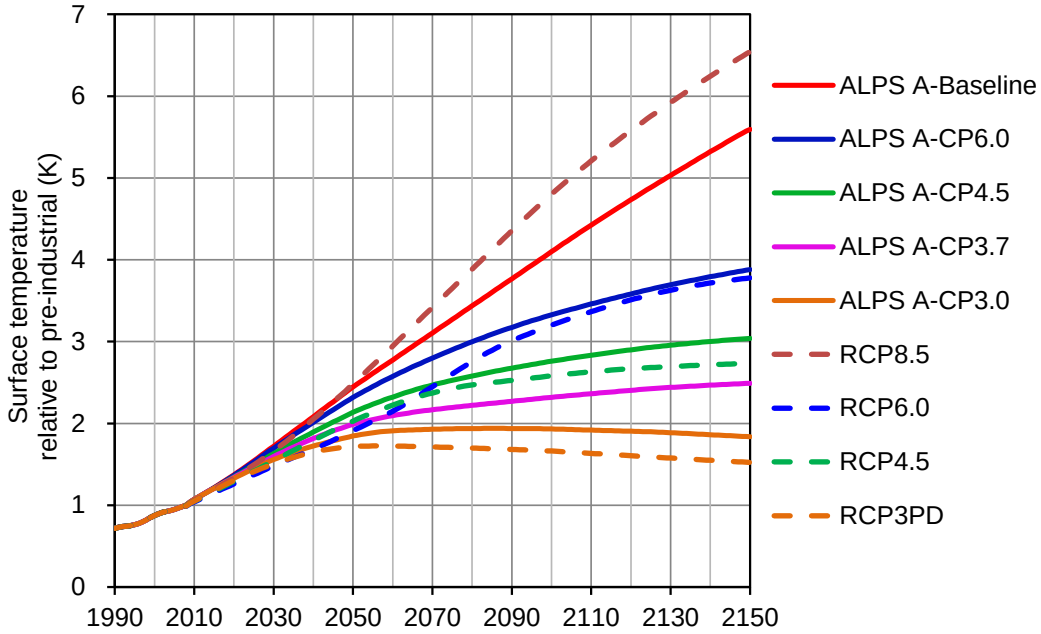
Figure 6.14



Not only the atmospheric CO2 concentration level of 430-480 ppm CO2eq but also of 480-530 ppm CO2eq will be able to expect to achieve the temperature level below 2 °C with over 50% probability.

GHG Concentration and Temperature Change for the RITE ALPS Scenarios





Equilibrium Climate Sensitivity: 3.0 °C