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Toward better understandings of uncertainties in climate change countermeasures and development of risk management strategies

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History of climate sensitivity judgment by IPCC and the sensitivity employed in the scenario assessments of the IPCC WG3 AR5

	Equilibrium climate sensitivity Likely range ("best estimate" or "most likely value")
Before IPCC WG1 AR4	**1.5–4.5°C (2.5°C)**
IPCC WG1 AR4	**2.0–4.5°C (3.0°C)**
IPCC WG1 AR5	**1.5–4.5°C (no consensus)**
Global mean temperature estimations for the long-term scenarios in the IPCC WG3 AR5 (employing MAGICC)	**2.0–4.5°C（3.0°C） [Based on the AR4]**

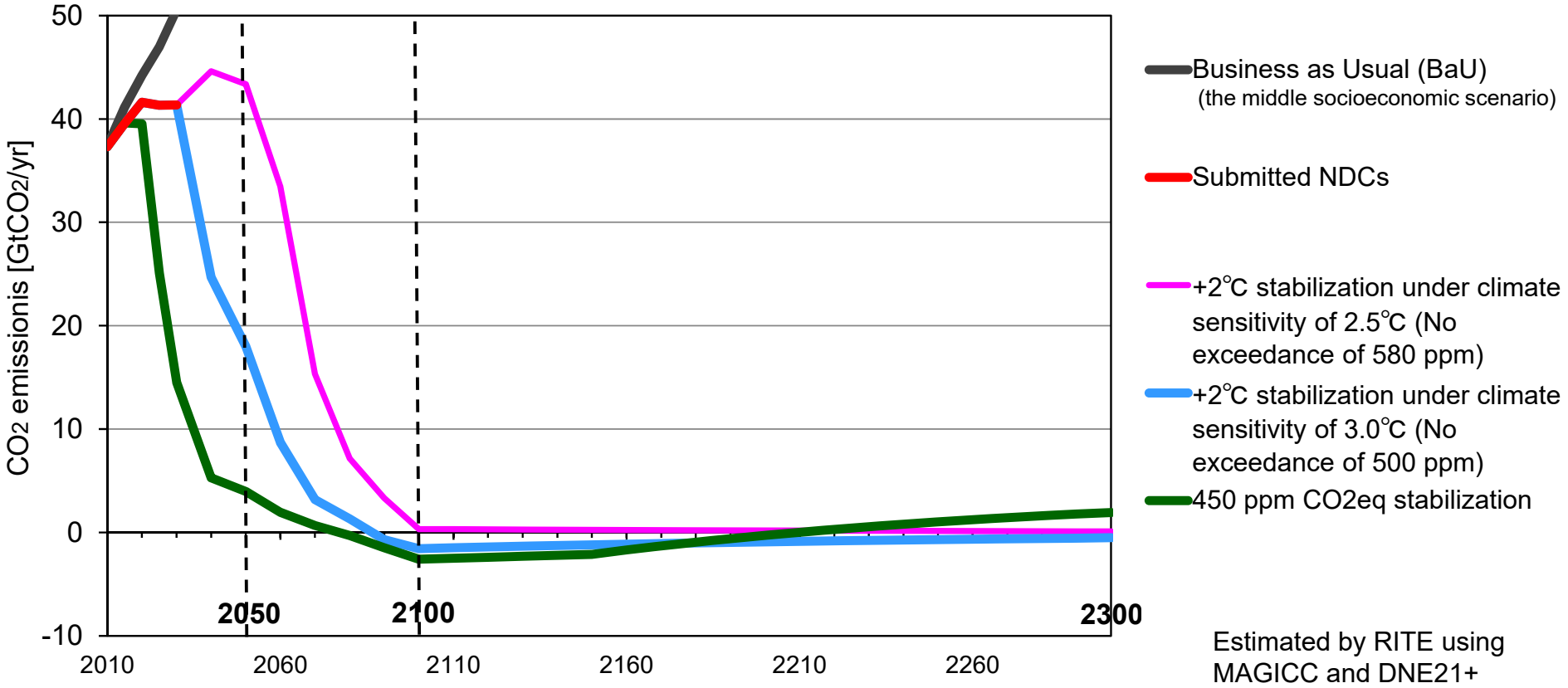
Same "likely" range

[The related descriptions of the SPM of WG1 AR5]

Likely in the range 1.5 °C to 4.5 °C (high confidence)
Extremely unlikely less than 1 °C (high confidence)
Very unlikely greater than 6 °C (medium confidence)
No best estimate for equilibrium climate sensitivity can now be given because of a lack of agreement on values across assessed lines of evidence and studies.

- **The equilibrium climate sensitivity, which corresponds to global mean temperature increase in equilibrium when GHG concentration doubles, is still greatly uncertain.**
- **AR5 WG1 judged the likely range of climate sensitivity to be 1.5–4.5 °C, in which the bottom range was changed to a smaller number than that in the AR4, based not only on CMIP5 (AOGCM) results but also other study results.**
- **AR5 WG3 adopted the climate sensitivity of AR4, which has the likely range of 2.0–4.5 °C with the best estimate of 3.0 °C, for temperature rise estimates of long-term emission scenarios.**

Global CO_2 emission profiles toward 2300 for the 2 °C targets



- The global CO_2 emissions should be nearly zero for a long-term period in the far future in any pathway to achieve temperature stabilization.
- On the other hand, the allowable global CO_2 emissions toward the middle of this century have a wide range according to the uncertainties in climate sensitivity (or achieving probability) even when the temperature target level is determined as a 2 °C. We should use this flexibility to develop several kinds of innovative technologies and societies.

Marginal CO2 abatement costs (Carbon prices) for the 2 °C target

SSP: "Shared Socioeconomic Pathways"

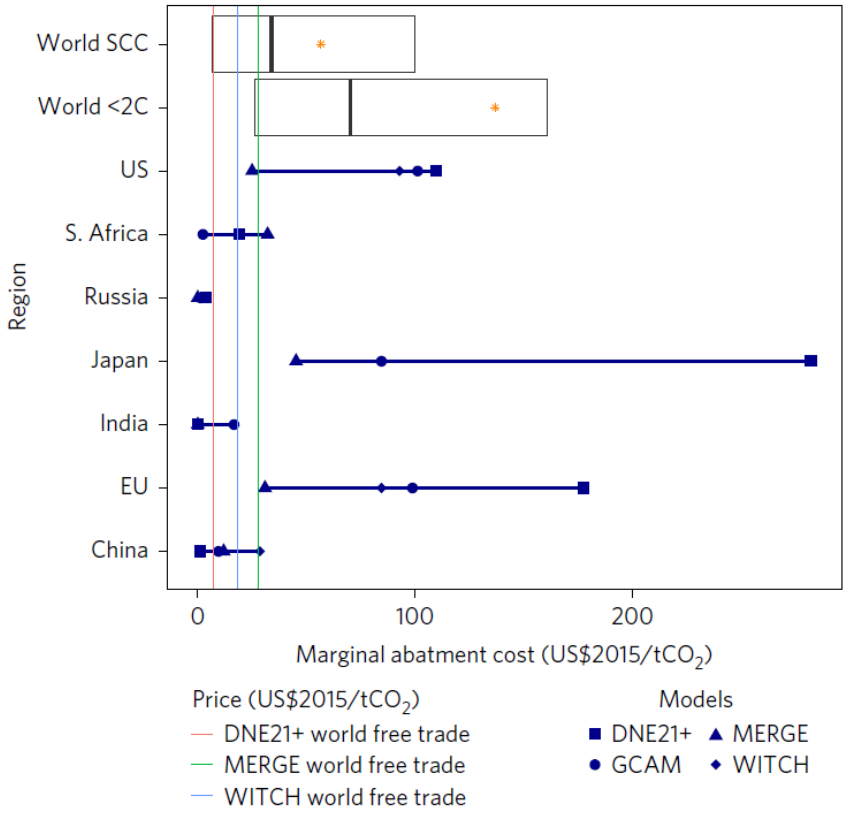
	SSP2 (Middle of the Road)			SSP1 (Sustainability)		
	+2°C stab. under climate sensitivity of 2.5°C	+2°C stab. under climate sensitivity of 3.0°C	450 ppm CO2eq stab. (climate sensitivity of 3.4°C)	+2°C stab. under climate sensitivity of 2.5°C	+2°C stab. under climate sensitivity of 3.0°C	450 ppm CO2eq stab. (climate sensitivity of 3.4°C)
2050	12	135	604	14	117	518
2100	408	427	457	134	140	143

Unit: $/tCO2 (real price); Uniform carbon prices among all nations are assumed.

Source) estimated by RITE DNE21+

- **The marginal abatement costs (carbon prices) for the 2 °C target are huge even under the global least cost measures (uniform carbon prices) except in the case of low climate sensitivity (2.5 °C) and by 2050.**
- **The carbon price in SSP1 that energy demands in the end-use sectors are much smaller than in SSP2 is much lower than that in SSP2.**
- **Technological and social innovations are definitely required for the 2 °C target to be achieved in harmony with other SDGs. (Newly emerging technologies such as AI, IoT etc. will induce social changes which may lower the energy demand.)**

CO_2 marginal abatement costs of the NDCs



Source: J. Aldy et al., Nature Climate Change, 2016

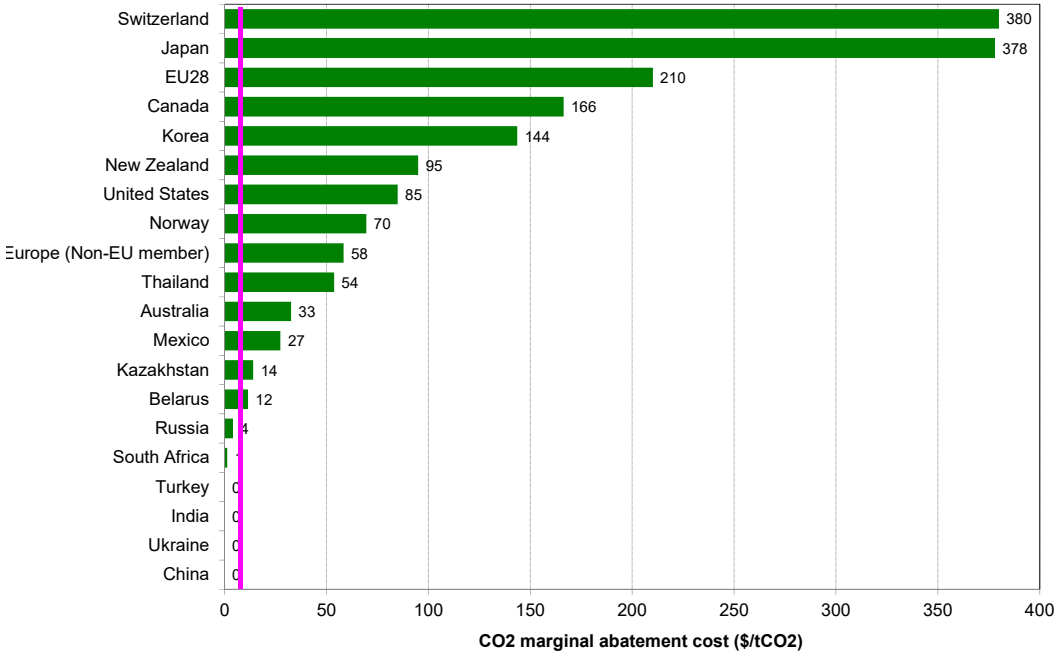
Average of 2025-2030

2030 (2025 for the U.S.)

【World GDP loss due to mitigation】

NDCs:0.38%; the global least cost:0.06%

The least cost (equal marginal abatement costs):6$/tCO2

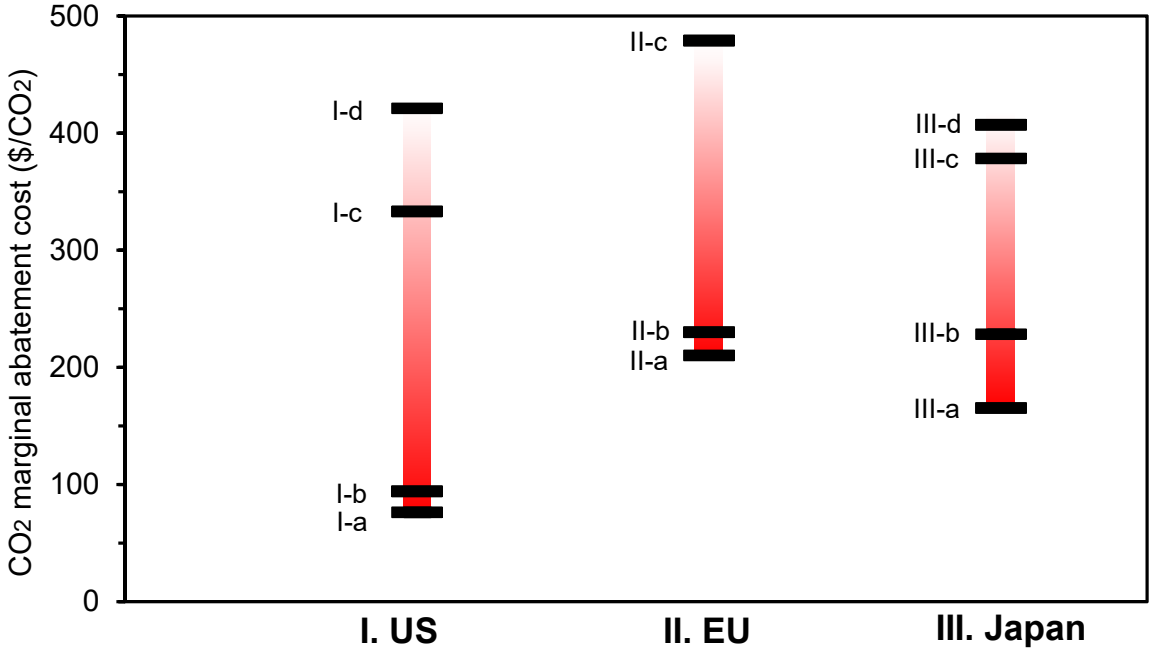


Source: K. Akimoto et al., Evol. Inst. Econ. Rev., 2016

- The estimated marginal abatement costs of NDCs are largely different among countries, and the mitigation costs are much larger than those under the least cost measures due to such large difference in marginal abatement costs.

- The difference will induce carbon leakages, and the leakages will reduce the effectiveness of global emission reductions.

CO_2 marginal abatement cost for the U.S, EU and Japan considering several kinds of policy constraints



I-a: -26%; the least cost
I-b: -28%; the least cost
I-c: -26%; power sector according to CPP
I-d: -28%; power sector according to CPP

* CPP: Clean Power Plan

II-a: the least cost
II-b: Brexit (-40% for UK)
II-c: splitting into ETS and non-ETS sectors

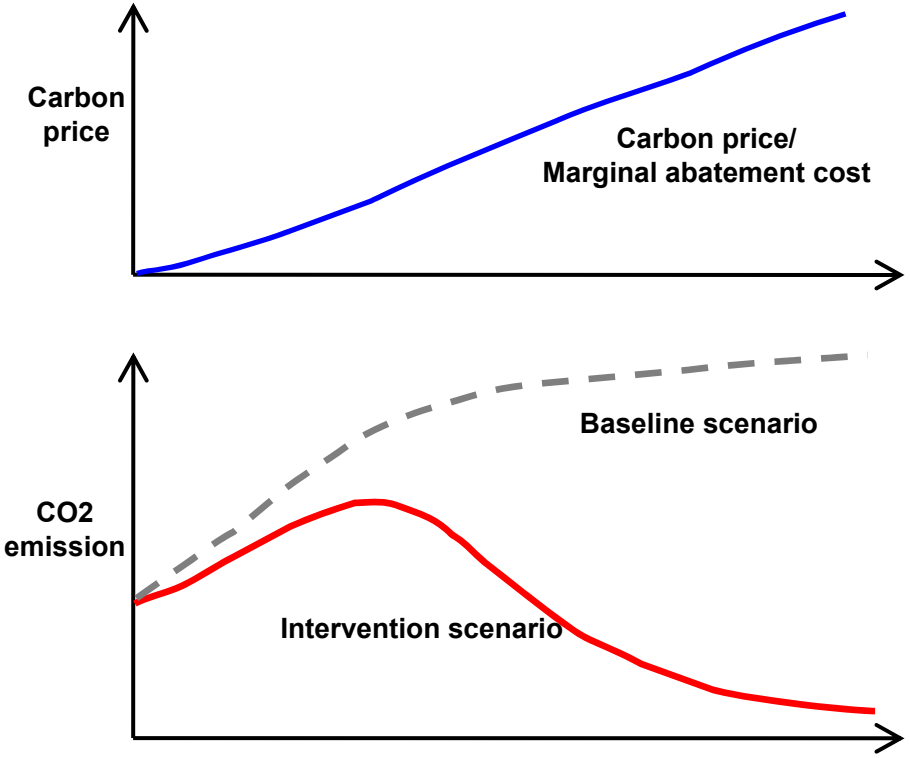
III-a: the least cost under nuclear of maximum 20%
III-b: the least cost under nuclear of maximum 15%
III-c: following the NDC including the energy mix (nuclear of 20%)
III-d: following the NDC including the energy mix but nuclear of 15%

Source: estimated by RITE DNE21+

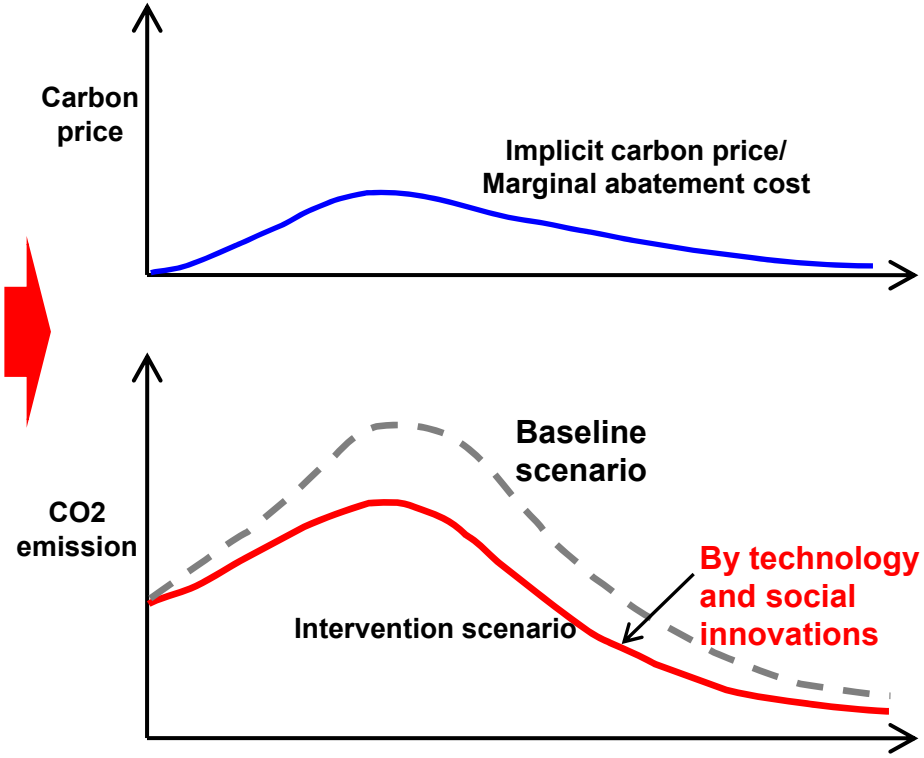
- It is not easy to achieve the least cost measures because there are several kinds of social and political constraints in each nation.
- The mitigation costs constrained by other policies can be much higher than those under the least cost measures.

Image of standard scenario by models and real world scenarios for deep cuts

Model world:
Ordinary technology progress



Realistic world requirement:
Innovations stimulated & implemented



Explicit high carbon prices such as over 100$/tCO$_2$ in real price are unlikely in a real world. Technology and social innovations resulting in low (implicit or explicit) carbon prices (including coordination of secondary energy prices) are key for deep emission cuts to be implemented.

Issues of IPCC

- Basically, the IPCC assessment reports are written relying on scientifically reviewed articles.
- In addition, the principle of IPCC is “not policy prescriptive but policy relevant”.
- Under such conditions, the IPCC reports have the dilemma that they are valuable in practice but not easily compatible with the realistic solutions considering economic, social and political constraints in the real world.

付録

The Assumed Scenarios for Obtaining the Emission Pathways Meeting the 2 °C and 1.5 °C targets

C.S. likely: 2.0-4.5°C, most likely:3.0°C by IPCC AR4 (=WG3 AR5)

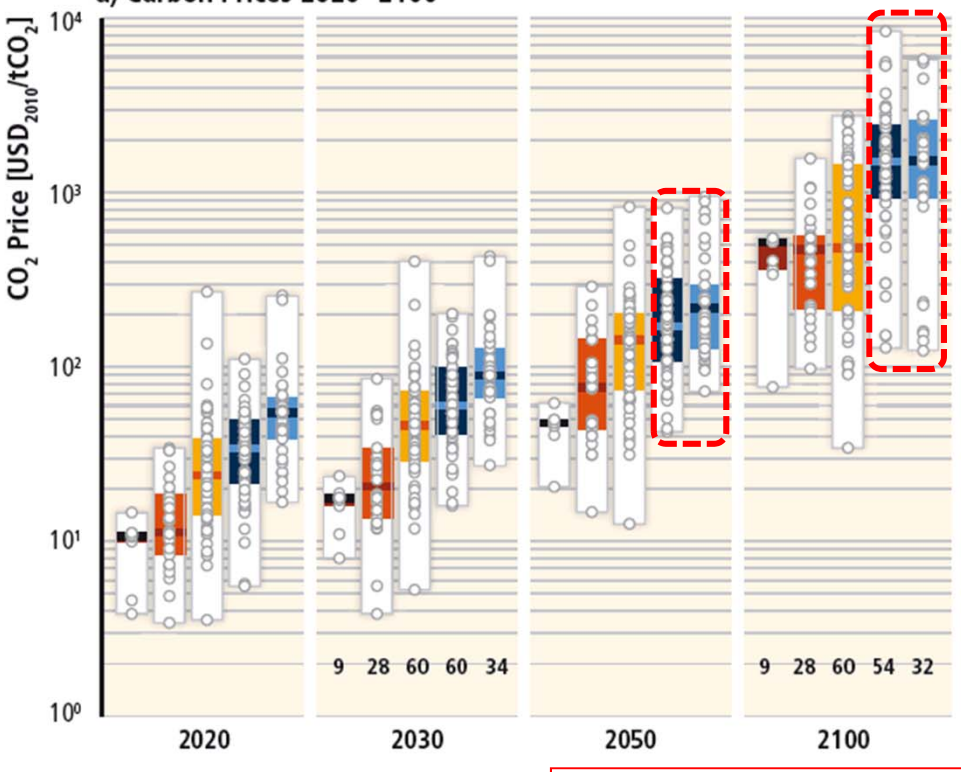
C.S. likely: 1.5-4.5°C, Most likely: 2.5°C by IPCC WG1 AR5+ TAR

Category by concentration in 2100 (ppm CO2eq)	Sub-category	Global GHG emissions in 2050 (relative to 2010)	Temperature in 2100 (°C, relative to 1850-1900)	Probability of not exceeding the temp. rise over 21st century (relative to 1850-1900)*		Probability of not exceeding the temp. rise over 21st century (relative to 1850-1900)*	
				1.5℃	2.0℃	1.5℃	2.0℃
[0] <430	Only a limited number of studies exist. (There are no scenarios in the AR5 DB.)			50%以上*		66%以上	
[1] 450 (430-480)	—	-72～-41%	1.5～1.7℃ (1.0～2.8)		66%以上	50%以上	
[2] 500 (480-530)	[2a] No exceedance of 530 ppm CO2eq	-57～-42%	1.7～1.9℃ (1.2～2.9)		50%以上		66%以上
	[2b] Exceedance of 530 ppm CO2eq	-55～-25%	1.8～2.0℃ (1.2～3.3)				
[3] 550 (530-580)	[2a] No exceedance of 580 ppm CO2eq	-47～-19%	2.0～2.2℃ (1.4～3.6)				50%以上
	[2b] Exceedance of 580 ppm CO2eq	-16～+7%	2.1～2.3℃ (1.4～3.6)				

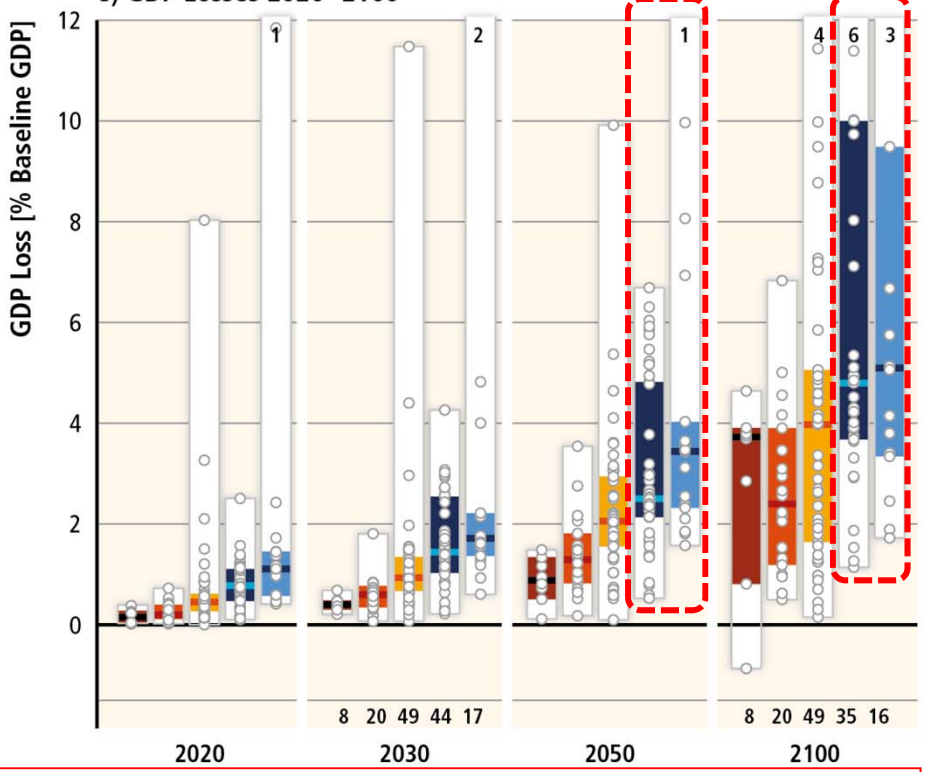
Source) IPCC AR5; * simply estimated by RITE

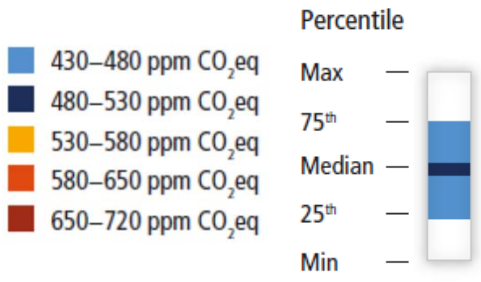
Huge costs are estimated for achieving the 2 °C target

Corresponding to 2 °C target



Corresponding to 2 °C target





Source) IPCC WG3 AR5

- According to the IPCC AR5, the CO_2 marginal abatement costs (carbon prices) for the 430-530 ppm CO_2eq (which are consistent with the 2 °C target) are about 1000-3000 $/t$CO_2$ (25-75 percentile) and 150-8000 $/t$CO_2$ (full range) in 2100.
- About 25% of the analyzed scenarios estimate global GDP losses of over 10%.
- The feasibility of such scenarios should be carefully examined in terms of various real world constraints.