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Evaluations on emission reduction efforts of INDCs and pathways to deep emission reductions beyond 2030

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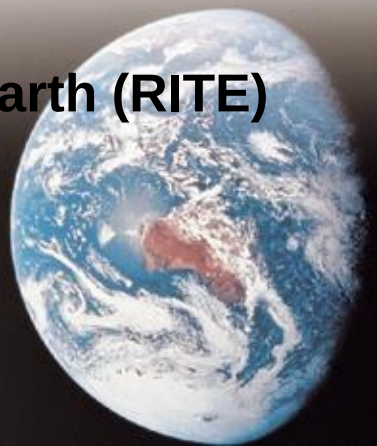

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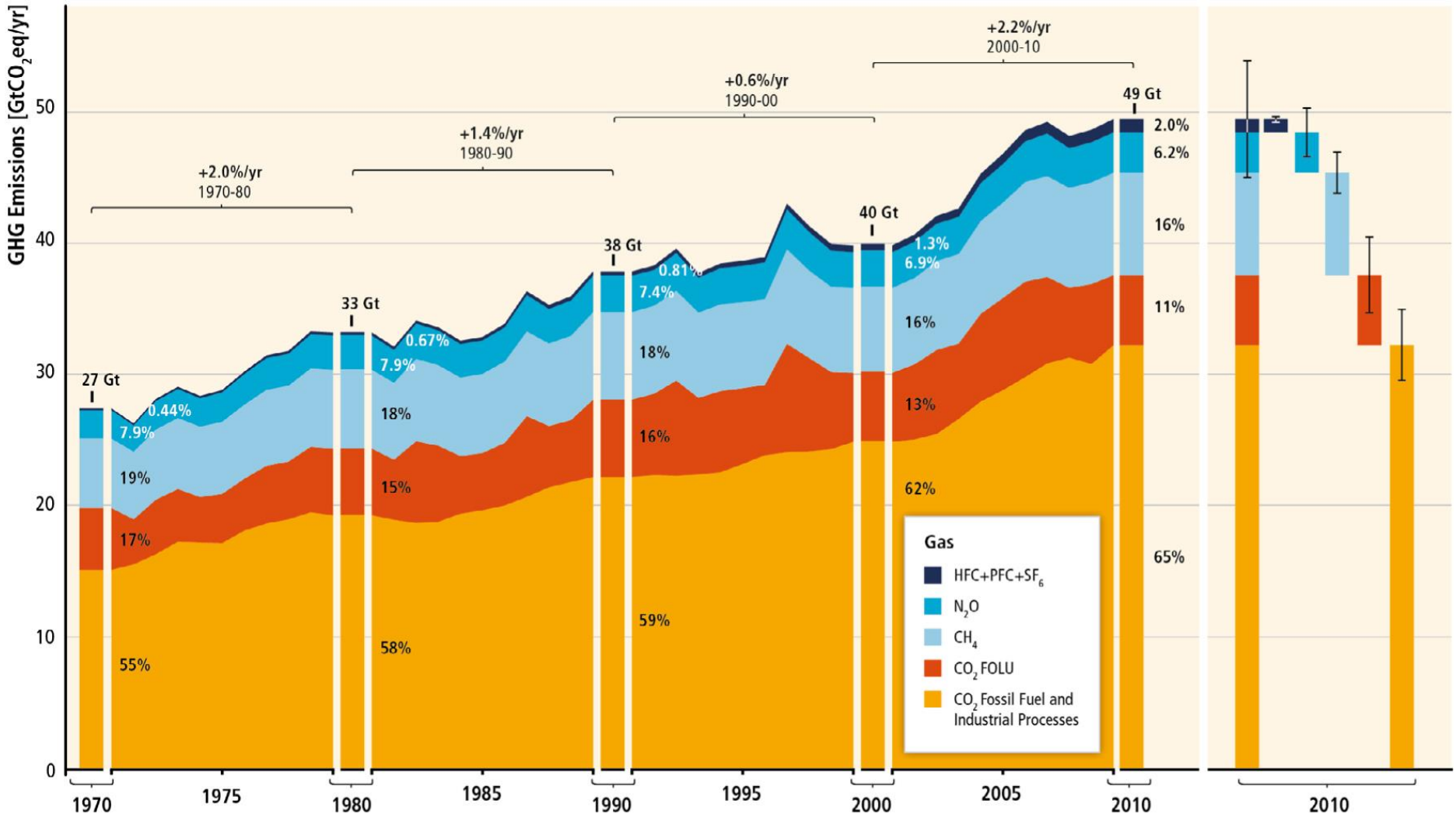
Background and objective

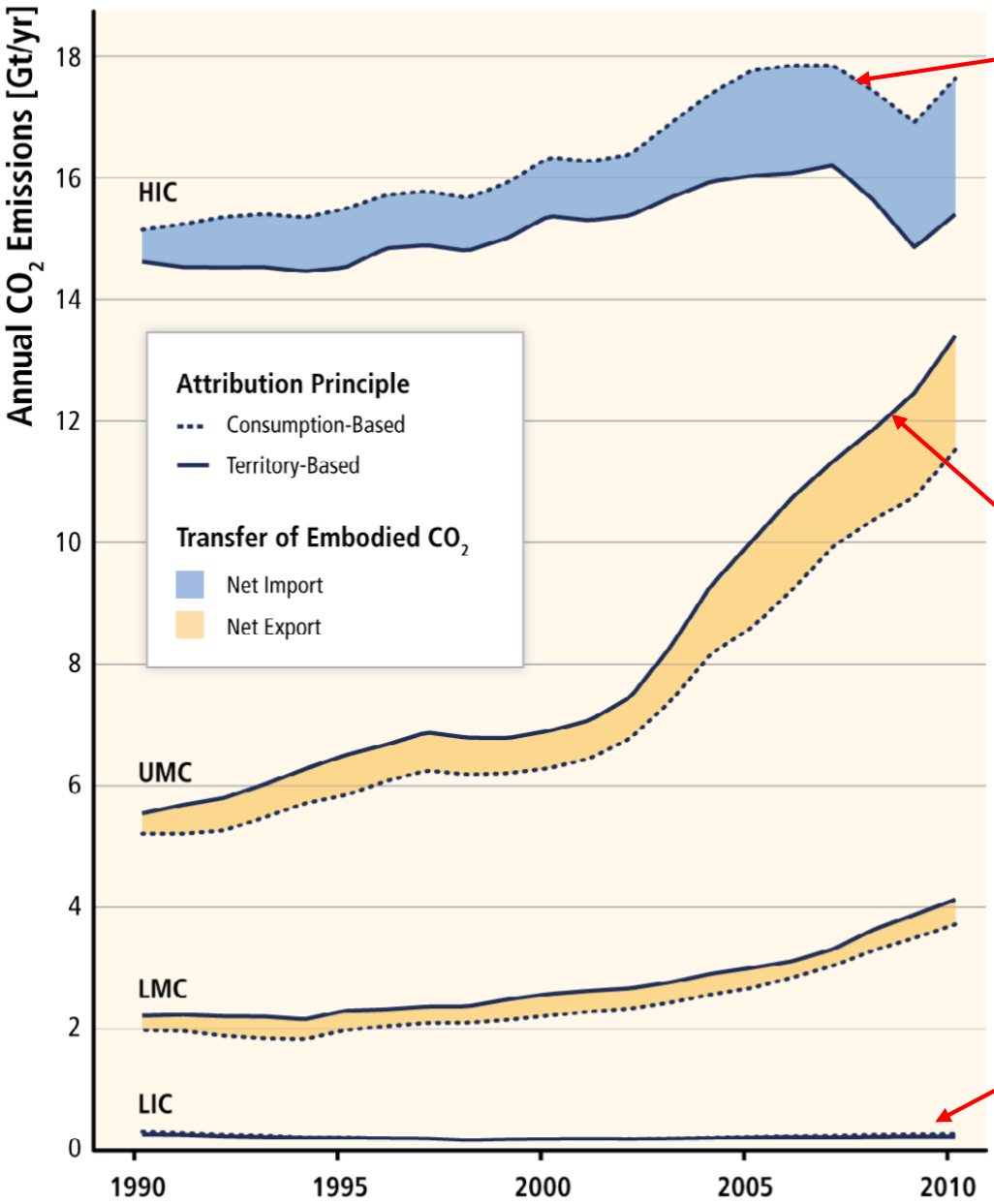
Trajectory of Global GHG Emission by Source



Source) IPCC AR5, 2014

The global emissions after 2000 increased more rapidly. The Kyoto Protocol was not able to exert large effects.

Trajectory of Global CO_2 Emission by Region



High income countries
($12,616 and more)

Consumption-based CO_2 emissions have not decreased even in HIC.

Upper middle income countries
($4,086 to $12,615)
(China, Brazil, Iran, Malaysia, South Africa etc.)

Rapid increase in CO_2 emissions

Lower middle income countries
($1,036 to $4,085)
(India, Indonesia, Philippine, Egypt etc.)

Tackling poverty; less priority to CO_2 emission mitigation

Low income countries
($1,035 and less)

Source) IPCC AR5, 2014

GHGs Emissions Covered by the Countries in Kyoto Protocol and Paris Agreement

Kyoto Protocol

22.0%

(The first commitment period)

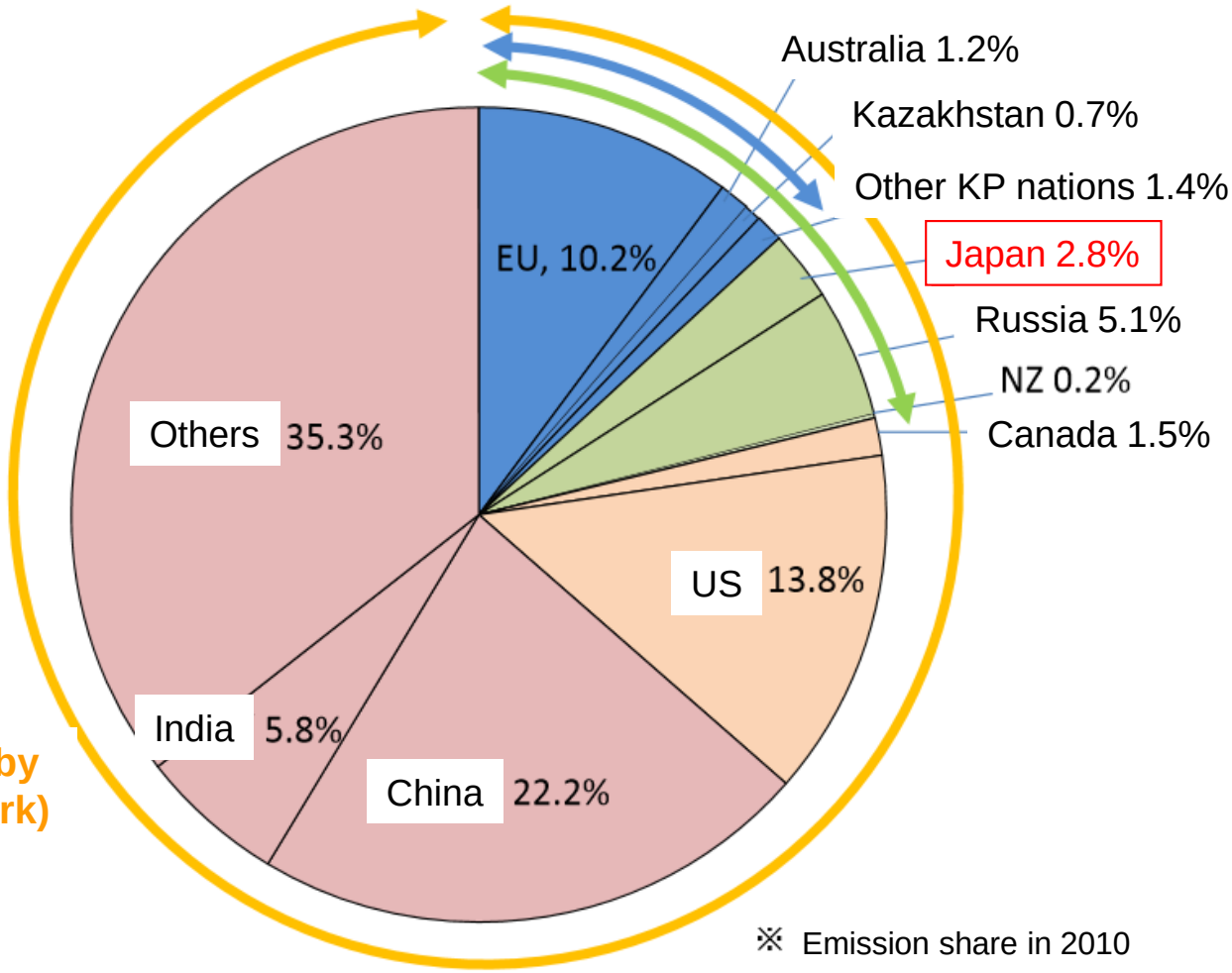
13.4%

(The second commitment period)

【COP21】

The agreement of participations by all countries (post-2020 framework)

159 nations and 1 regions that have submitted their NDCs by Dec. 14. (over 95% of global GHG emissions)



※ Emission share in 2010

Source: METI

Background and objectives of ALPS project and its major topics

Climate change is a very complex issue. Effectiveness of response measures in the real world are important. The aim of the ALPS project is to support the developments of international frameworks to achieve green growth and effective response measures through better understandings of technologies, economics, policies etc. and quantitative analyses and evaluations.

【major topics】

- **Risk management strategy for climate change responses**
  - **Estimates of climate change damages, adaptations, and mitigation costs and their uncertainties**
  - **Long-term target and the corresponding emission pathways**
  - **Risk management strategy for climate change responses under uncertainties etc.**
- **Better economic understandings and analysis for real green growth**
  - **Considering the possibilities and limitations of removing energy saving barriers, relationship between climate change and air pollution mitigation, etc., and model analyses**
  - **Estimations of international energy productivity gaps (comparisons between the U.S. and Japan) competitiveness and green growth**
  - **Analyses for international constraint for funding to coal power etc.**
- **Climate change mitigation measures, particularly the systems measures.**
  - **hydrogen systems (total systems including supply, transport, consumption)**
  - **systems of building, and transportations etc.**
- **Analyses regarding international frameworks, discussions and policy interests**
  - **Evaluations of post-2020 emission reduction targets of NDCs**
  - **Contributions to international model comparison projects etc.**

The Paris Agreement – Submissions of NDCs and Reviews –

- "Each party shall prepare […] nationally determined contributions that intends to achieve." (Article 4 Paragraph 2); "Each Party shall communicate a nationally determined contribution every five years" (Article 4 Paragraph 9).
- "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution" (Article 4 Paragraph 3).
- However, the Paris Agreement does not specify each country's GHG emissions reductions target (one of the major differences with the Kyoto Protocol).
- In order to ensure an effective implementation, transparency is enhanced: all Parties' implementation progress is shared and reviewed with flexibility (Article 13).

Appropriate reviews for the NDCS in the Paris Agreement processes are important in order to make worldwide effective GHG emission reductions.

The Paris Agreement – Long-term Targets –

- **"To hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels" (Article 2, Paragraph 1(a) (According to the COP21 Decision, IPCC is invited to write "a special report in 2018 on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways")**
- **"In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, […] and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century"(Article 4, Paragraph 1)**
- **All Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies (Article 4 Paragraph 19) (and the time horizon was clarified until 2020 according to the COP21 Decision)**
- **In order to assess the world's progress towards the Agreement's goal and long-term targets, the state of implementation will be examined every 5 years. ("Global stocktake", first time in 2023)**
- **Besides, major economies announced the initiative by private and public sectors for research and development of clean energies "Mission innovation".**

Evaluations of NDCs (GHG emission reduction targets)

Principals of Indicators for Measuring Fair and Equitable Emission Reduction Efforts

Aldy & Pizer (2014) pointed out the importance of reviewing each country's pledge in terms of emissions reductions:

- **The metrics used for the comparative analysis of countries' emissions reduction efforts have to comply with the following principles:**
  - **Comprehensive: in order to capture the entire effort undertaken**
  - **Measureable: direct or indirect measurement possible**
  - **Replicable: transparent enough as to be easily replicated**
  - **Universal: applicable to as broad a set of countries as possible**

- **There is no unique indicator to rate the fairness and equity of emissions reduction efforts. It is thus important to adopt a multifaceted approach using a number of relevant indicators.**

Aldy & Pizer, Comparability of Effort in International Climate Policy Architecture, Harvard Kennedy School (2014)

How to measure the comparability of efforts

The submitted INDCs include the targets of emissions reduction from different base years, CO_2 intensity, and CO_2 emission reductions from baseline (w/w.o. clear definition of baseline). We need to interpret them through comparable metrics to measure the efforts:

- **Simple metrics (easily measurable and replicable)**
  - **Emissions from the same base year**

  etc.
- **More advanced metrics (more comprehensive, but require forecasts)**
  - **Emission reduction ratios from baseline emissions**
  - **Emissions per unit of GDP**

  etc.
- **Most advanced metrics (most comprehensive, but require modeling)**
  - **Energy price impacts**
  - **Marginal abatement cost (per ton of CO_2)**
  - **Abatement costs as a share of GDP**

  etc.

Employed indicators for measuring emissions reduction efforts (1/2)

Emissions reduction efforts evaluation method		Framework	Notes
Emissions reduction ratio from base year (only for OECD countries or Annex I countries)	Compared to 2005	When baseline emissions are expected to stagnate, it is more relevant to simply compare the projected reduction rates (all the more since there are uncertainties regarding the BAU). This is why we use the reduction ratio compared to BAU for OECD countries only - on the other hand, such an approach would be irrelevant for countries where emissions are expected to grow substantially.	Most countries use 2005 as their base year (as a matter of fact, 1990 seems too far in the past to be used as a base year to evaluate the emissions reduction effort for upcoming emissions)
	Compared to 2012 (or 2010)		This seems a relatively good choice to evaluate future efforts as it allows assessing reduction ratios in comparison with recent circumstances.
Emissions per capita (only for non-OECD countries or non-Annex I countries)	Absolute value	For OECD countries, we adopt the reduction ratio from base year instead of the absolute value of emissions per capita.	As it is highly dependent on the country's level of economic activity and situation in general, it can be difficult to assess emissions reduction efforts through this indicator.
CO2 intensity (GHG emissions per GDP)	Absolute value	Reveals what level of CO2 emissions corresponds to what degree of economic activity	It can easily reach bad values for countries with a low GDP; it is also highly dependent on the country's industry structure.
	Improvement rate (compared to 2012 or 2010)	As it removes the bias due to the fact that economic growth has changed compared to the base year, it reveals the real effort in emission reduction.	For countries with a low GDP, carbon intensity can improve greatly just due to high economic growth.

Employed indicators for measuring emissions reduction efforts (2/2)

Emissions reduction efforts evaluation method		Framework	Notes
Emissions reduction ratio compared to BAU		It allows taking into account the difference of economic growths, etc.	It puts aside past efforts in energy savings and abatement potential of renewables.
CO2 marginal abatement cost (carbon price)		This is a particularly relevant indicator to assess reduction efforts as it contains countries' differences in terms of economic growth, energy savings efforts, abatement potential of renewables.	Past measures such as taxes on energy are out of the scope (however, one must keep in mind that, as energy savings efforts have already been made in the past, this may lead to higher estimates of marginal abatement costs.)
Retail prices of energy (electricity, city gas, gasoline, diesel)	Weighted average of historical data from 2012 or 2010	While marginal abatement costs show the additional effort to be made, this indicator also includes the efforts made in the baseline.	Market data is available for ex-post evaluation, but for ex-ante evaluation, only model-based estimates are available which makes uncertainties rather high.
Emission reduction costs per GDP		As marginal abatement costs do not take into account the economy's ability to bear such an effort, this indicator does.	Uncertainties are high as this is a model-based estimation.

Evaluated INDCs (1/2)

The 119 INDCs submitted as of October 1st, 2015 were evaluated.
As of October 1st, 2015, 119 INDCs had been submitted, and representing about 88 per cent of global emissions in 2010.
Comprehensive evaluations of emission reduction efforts were only for 20 countries (see below) due to the limited regional resolution of the model.

	2020 (Cancun Agreements)	Post-2020 (INDCs)
United States	-17% compared to 2005	**-26% to -28% by 2025 compared to 2005**
Canada	-17% compared to 2005	**-30% by 2030 compared to 2005**
EU28	-20% compared to 1990	**-40% by 2030 compared to 1990**
Switzerland	-20% compared to 1990	**-50% by 2030 compared to 1990 (-35% by 2025 compared to 1990)**
Norway	-30% compared to 1990	**-40% by 2030 compared to 1990**
Japan	-3.8% compared to 2005*	**-26% by 2030 compared to 2013**
Australia	-5% compared to 2000	**-26% to -28% by 2030 compared to 2005**
New Zealand	-5% compared to 1990	**-30% by 2030 compared to 2005**
Russia	-15 to -25% compared to 1990	**-25% to -30% by 2030 compared to 1990**

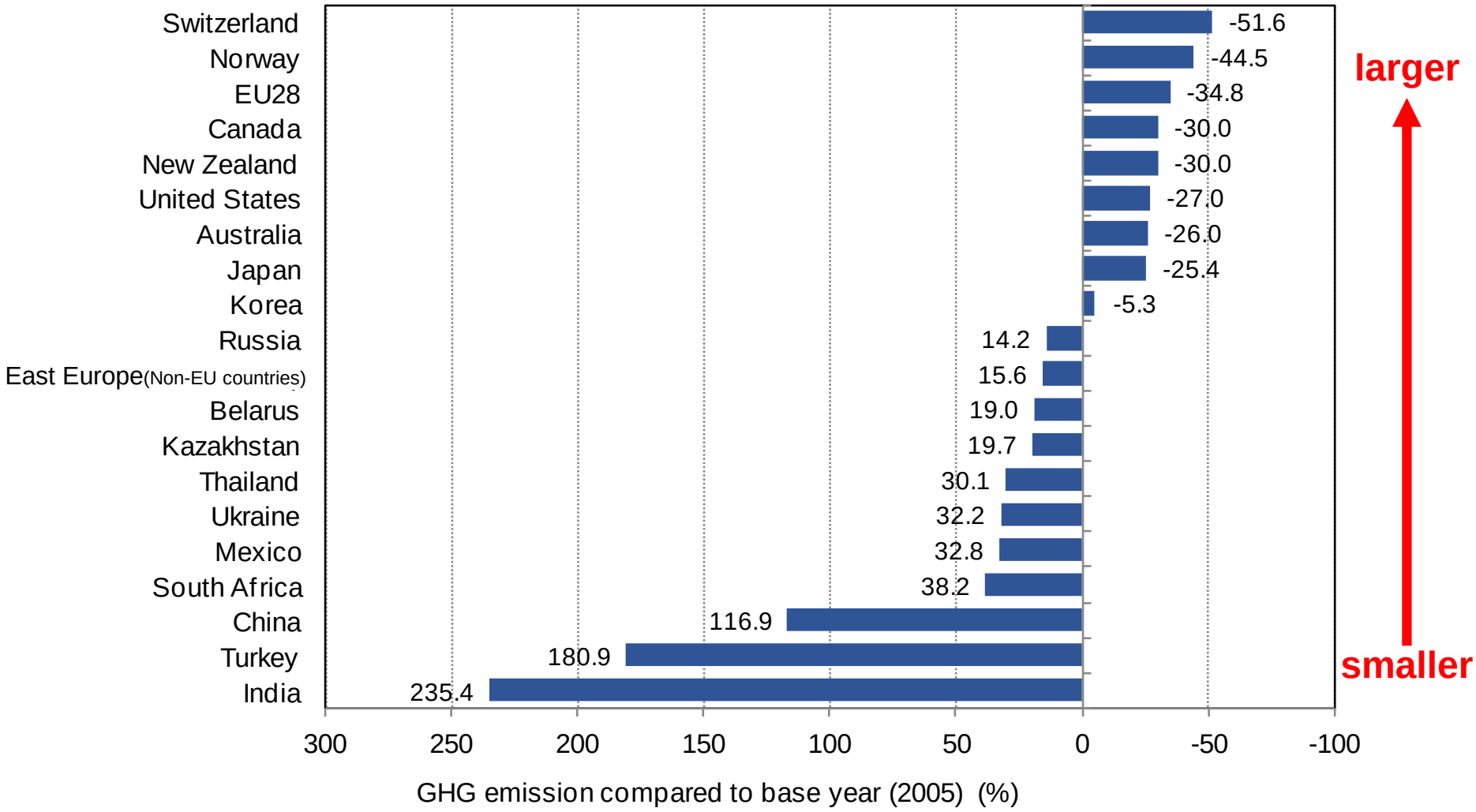
Note: More ambitious emission reduction targets had been submitted as “conditional “ targets from some countries, but they are not included in this table.
* Emission reduction target assuming zero nuclear power

Evaluated INDCs (2/2)

	2020 (Cancun Agreements)	Post-2020 (INDCs)
Non-EU Eastern Europe	—	**-19% by 2030 compared to 1990***
Ukraine	-20% compared to 1990	**-40% by 2030 compared to BAU**
Belarus	-5 to -10% compared to 1990	**-28% by 2030 compared to 1990**
Kazakhstan	-15% compared to 1992	**-15% by 2030 compared to 1990**
Turkey	—	**-21% by 2030 compared to BAU**
Korea	-30% compared to BAU	**-37% by 2030 compared to BAU**
Mexico	-30% compared to BAU	**-25% by 2030 compared to BAU** **(-22% by 2030 compared to BAU in GHG)**
South Africa	-34% compared to BAU	**614MtCO_2eq/yr by 2030**
Thailand	-7 to -20% compared to BAU (Energy and transportation sectors)	**-20% by 2030 compared to BAU**
China	To reduce CO_2/GDP by -40 to -45% compared to 2005	**To reduce CO_2/GDP by -60 to -65% by 2030 compared to 2005 (To achieve the peaking of CO_2 emissions around 2030 and making best efforts to peak early)**
India	To reduce GHG/GDP by -20 to -25% compared to 2005	**To reduce GHG/GDP by -33 to -35% by 2030 compared to 2005**

* The reduction rate was estimated from the total emissions by the INDCs of Albania, Makedonia, Moldova, and Serbia.
** Emission reduction target of Mexico includes black carbon.

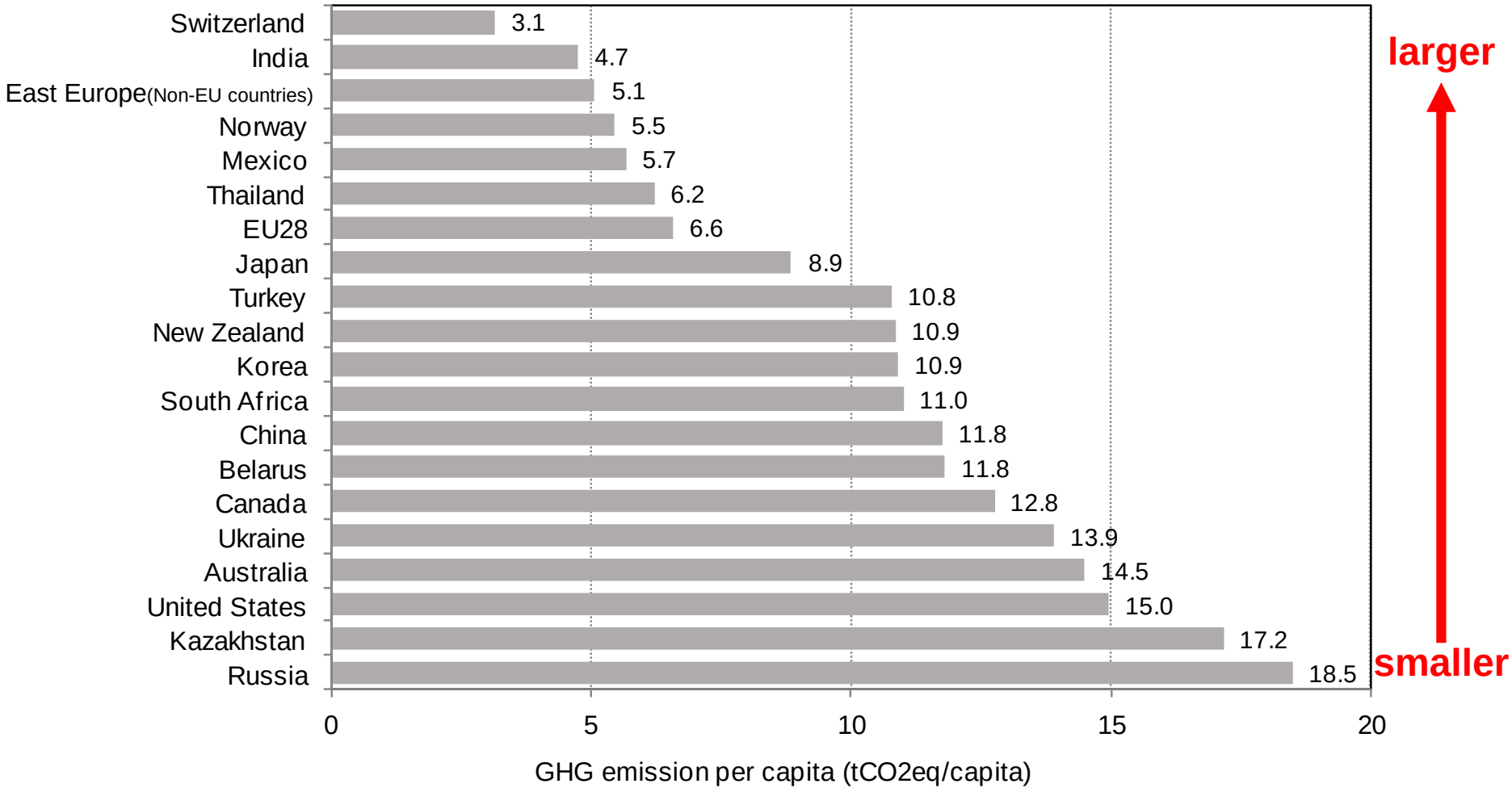
International comparison of emission reduction ratios from the base year of 2005



* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

Note) This indicator was employed only for OECD countries or Annex I countries for the integrated ranking.

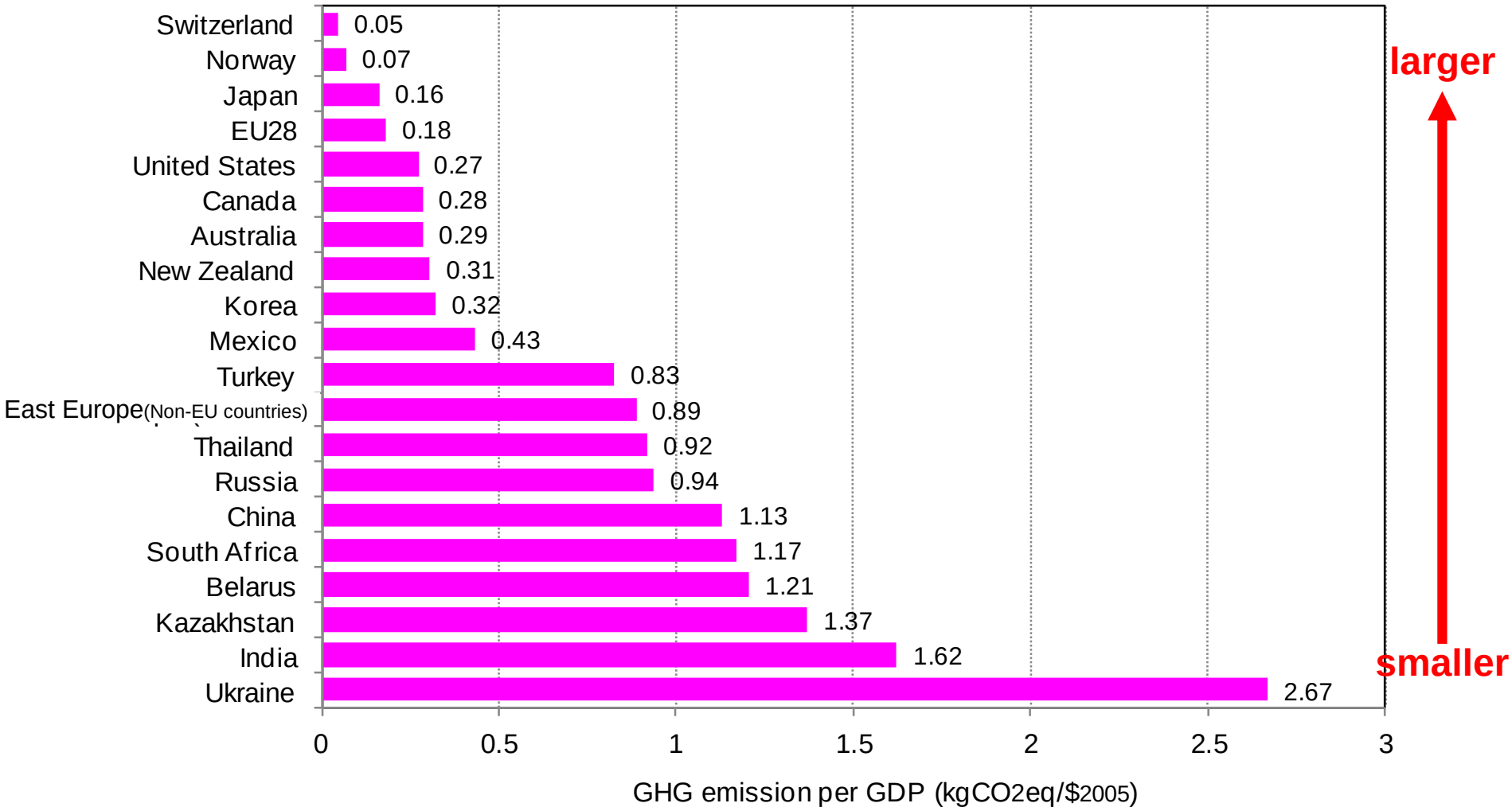
International comparison of GHG emissions per capita



* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

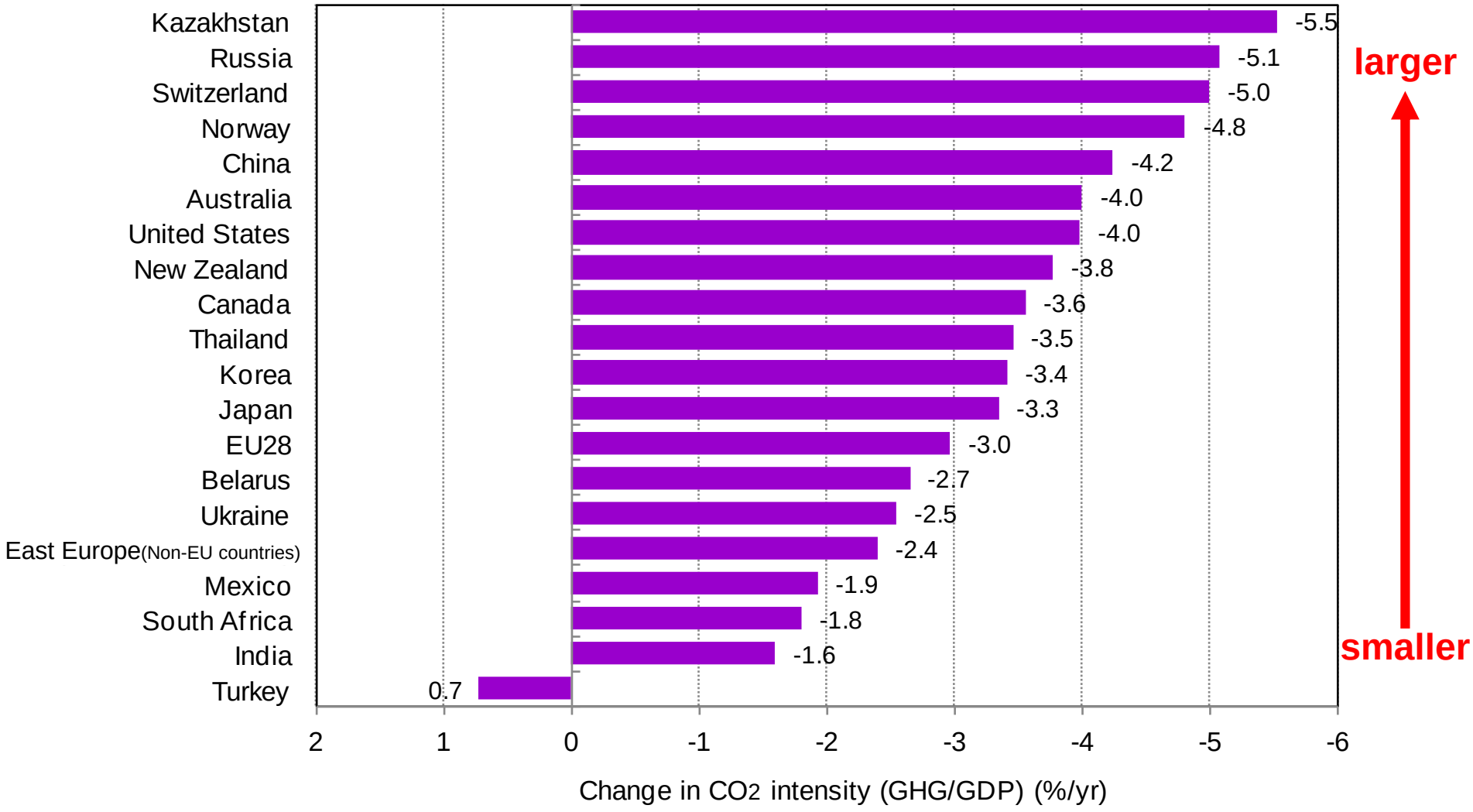
Note) This indicator was employed only for Non-OECD countries and Non-Annex I countries for the integrated ranking.

International comparison of GHG emissions per GDP (MER)



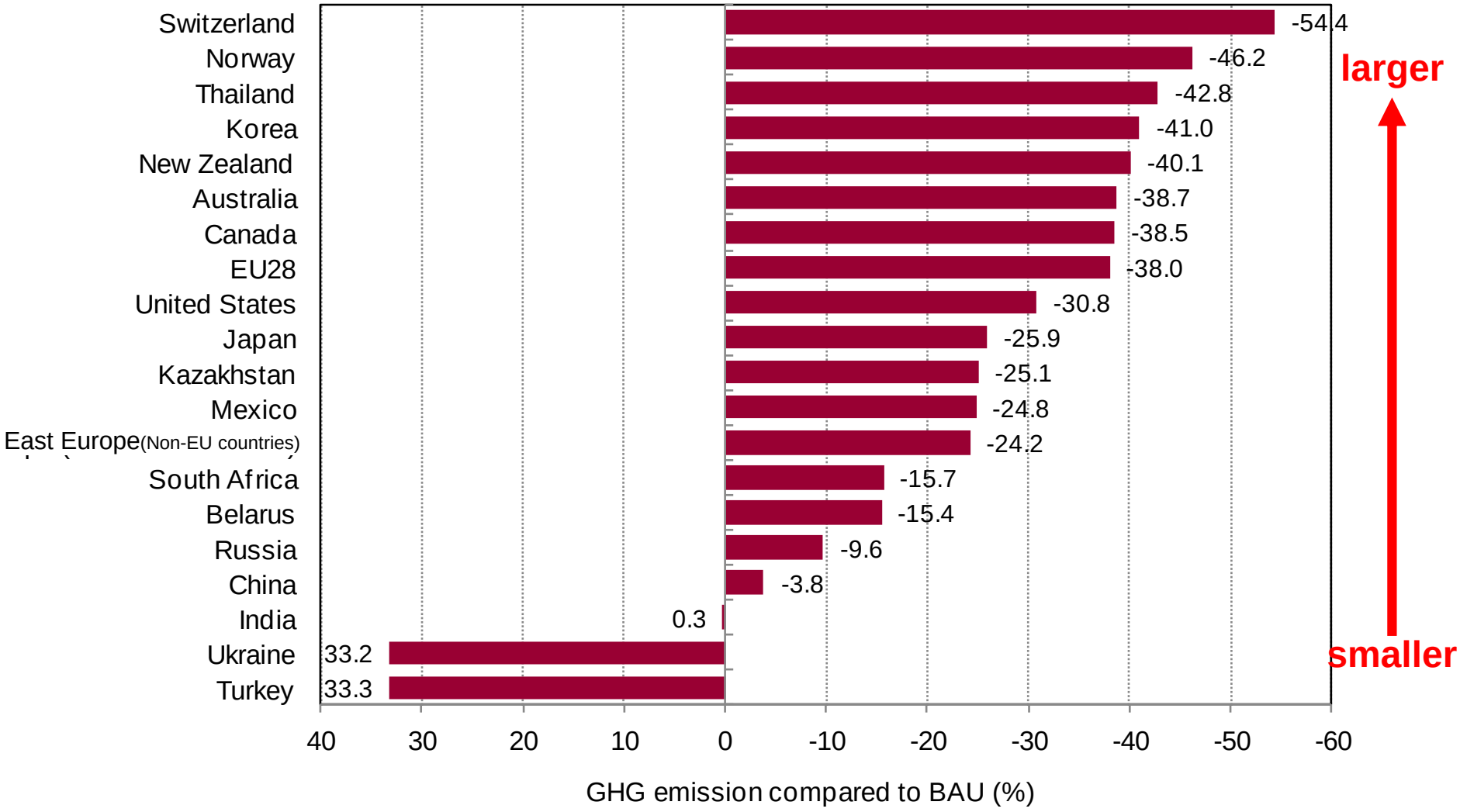
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

International comparison of change in CO2 intensity (GHG/GDP)



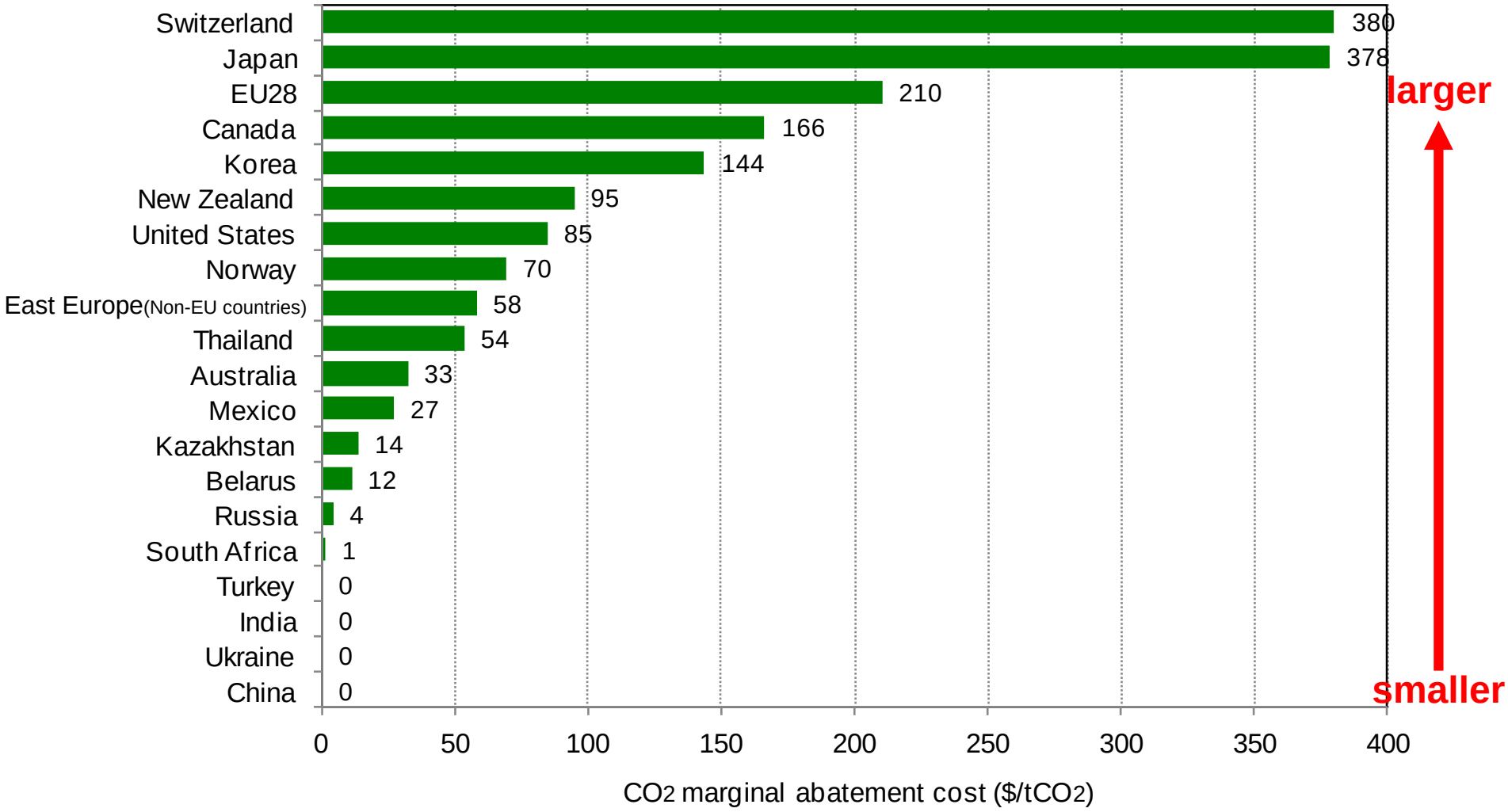
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

International comparison of emissions reduction ratio compared to BAU (Baseline)



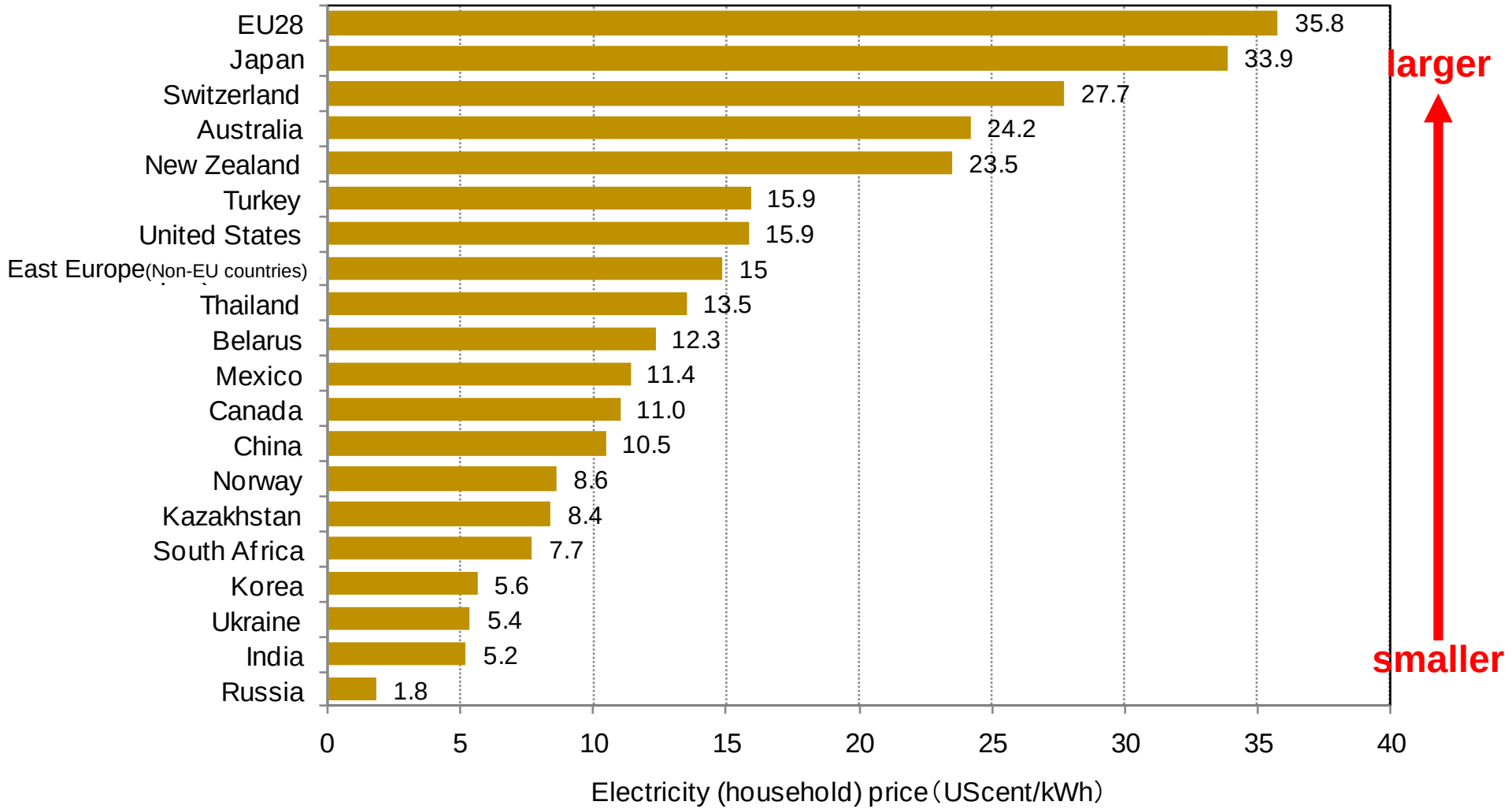
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

International comparison of CO_2 marginal abatement costs



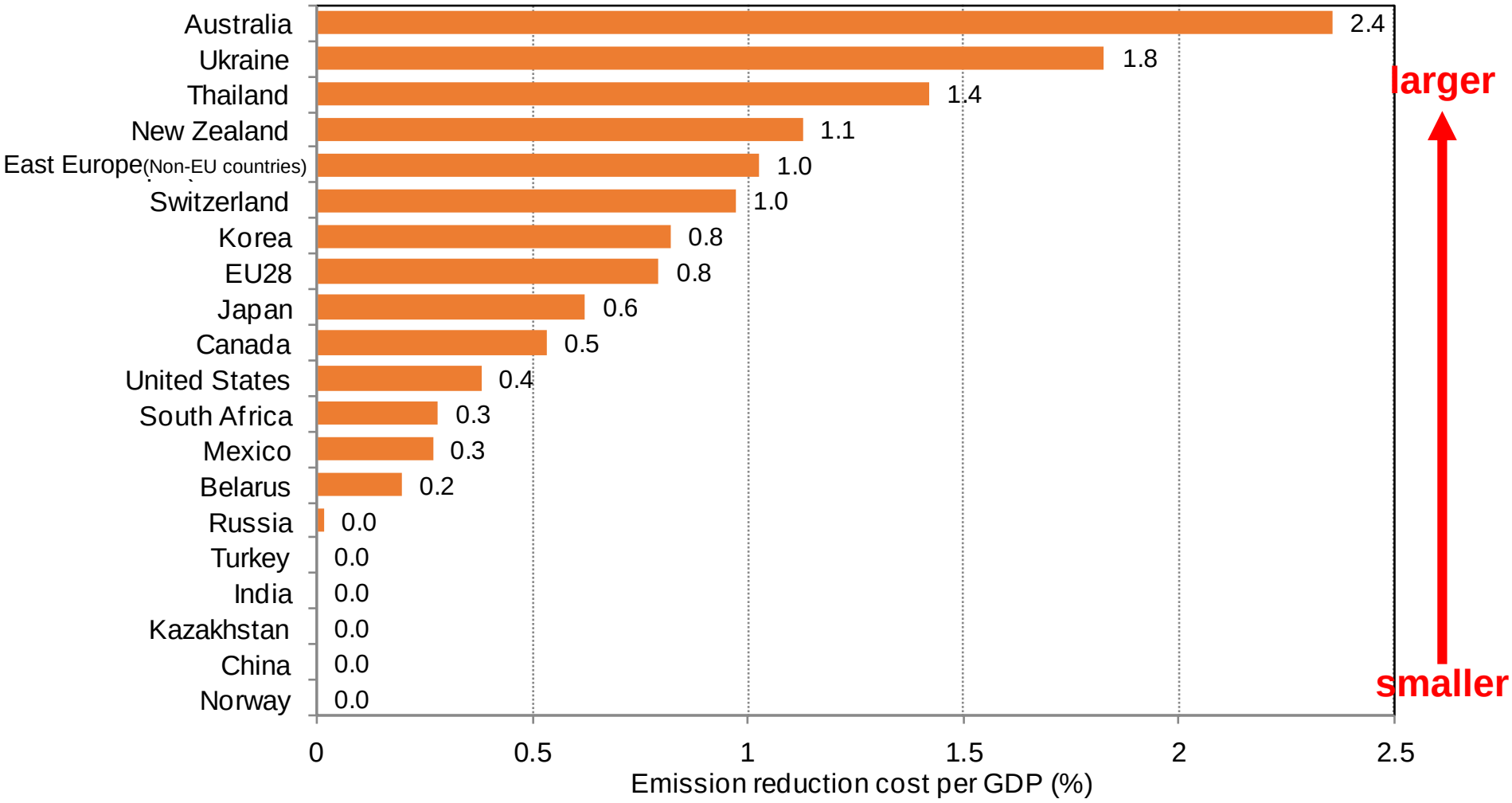
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

International comparison of retail prices of energy (electricity)



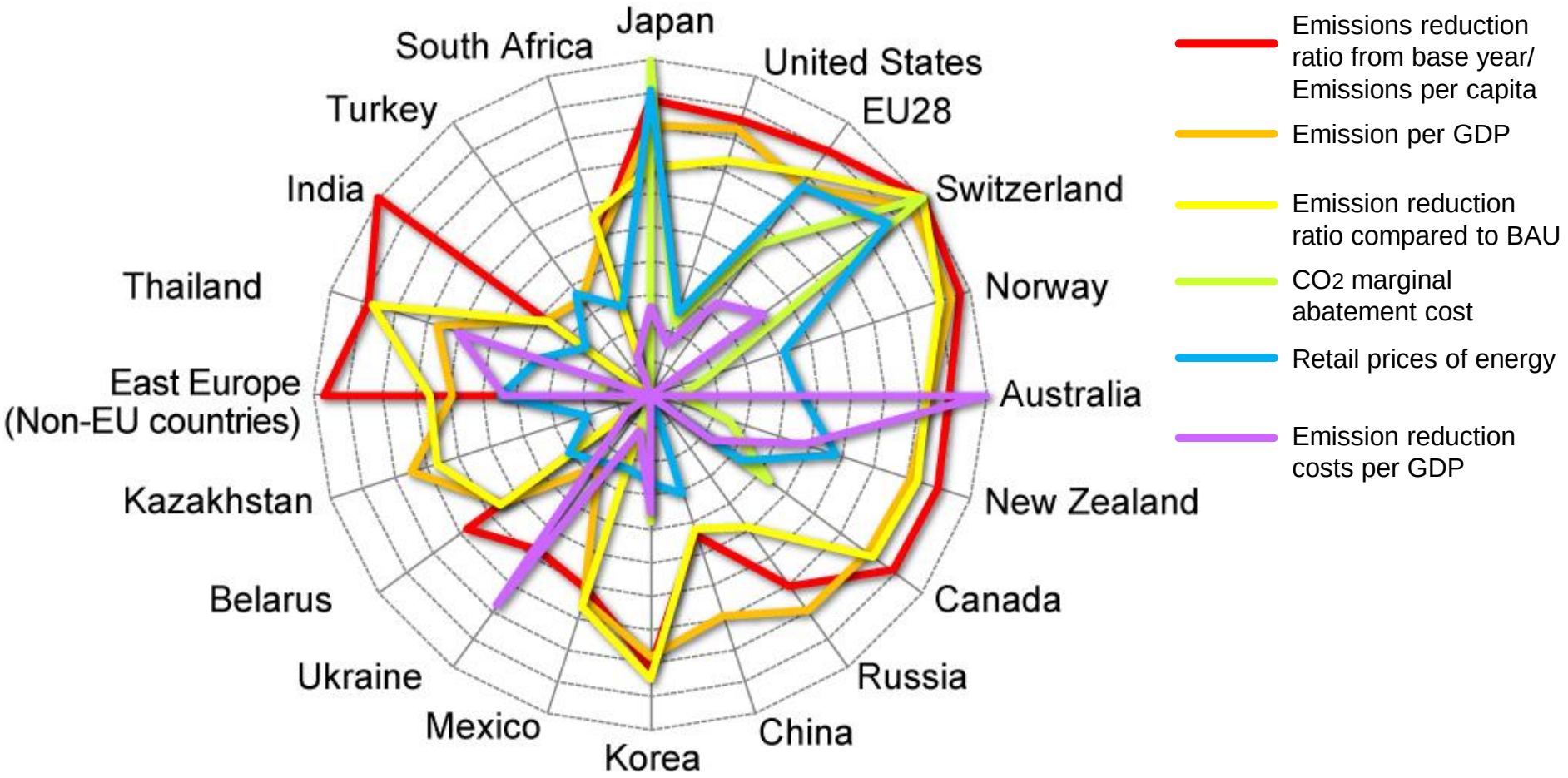
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

International comparison of emission reduction costs per GDP



* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

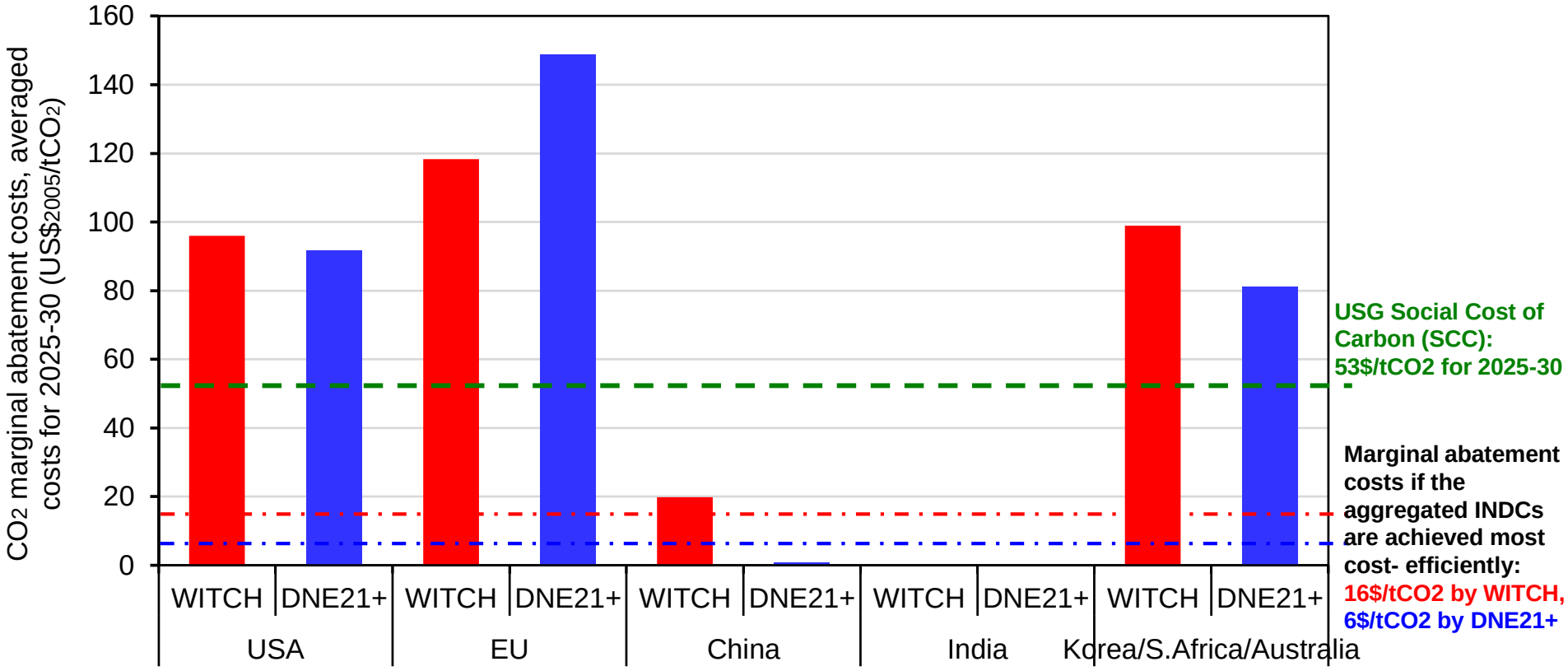
Ranking index of emissions reduction efforts (ambition) of INDCs by indicator



The wider the radar chart is, the greater the emission reduction efforts (ambition) are.

Many indicators (excepting emission reduction costs per GDP) of Switzerland and Japan were evaluated to have high rankings. CO_2 marginal abatement cost of Australia is not high, but the emission reduction cost per GDP is large.

Marginal abatement costs by two models (RITE DNE21+ and FEEM WITCH)



Source: B. Pizer, J. Aldy, R. Kopp, K. Akimoto, F. Sano, M. Tavoni

- The marginal abatement costs vary across models for some countries, but are comparable for many countries/regions.
- The CO_2 marginal abatement costs of the INDCs of OECD countries are much higher than the marginal cost that is estimated assuming that the total reductions are achieved most cost-efficiently (globally uniform marginal abatement cost).

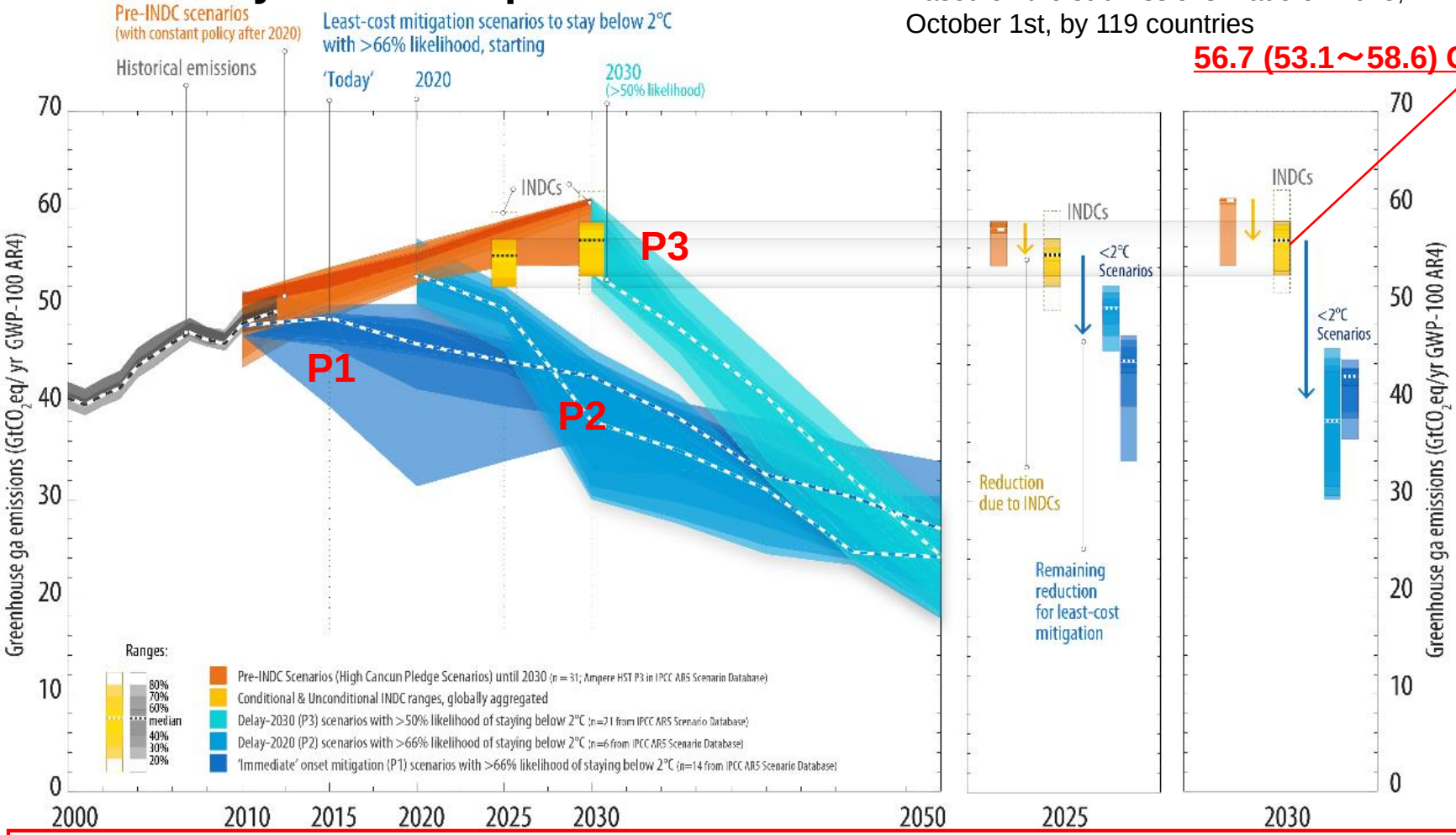
The relationship between the global emission estimated from the NDCs and the long-term temperature goal (2 °C/1.5°C target), and required emission reductions beyond 2030

GHG emission outlook of NDCs (UNFCCC estimate)

INDC Synthesis Report of UNFCCC

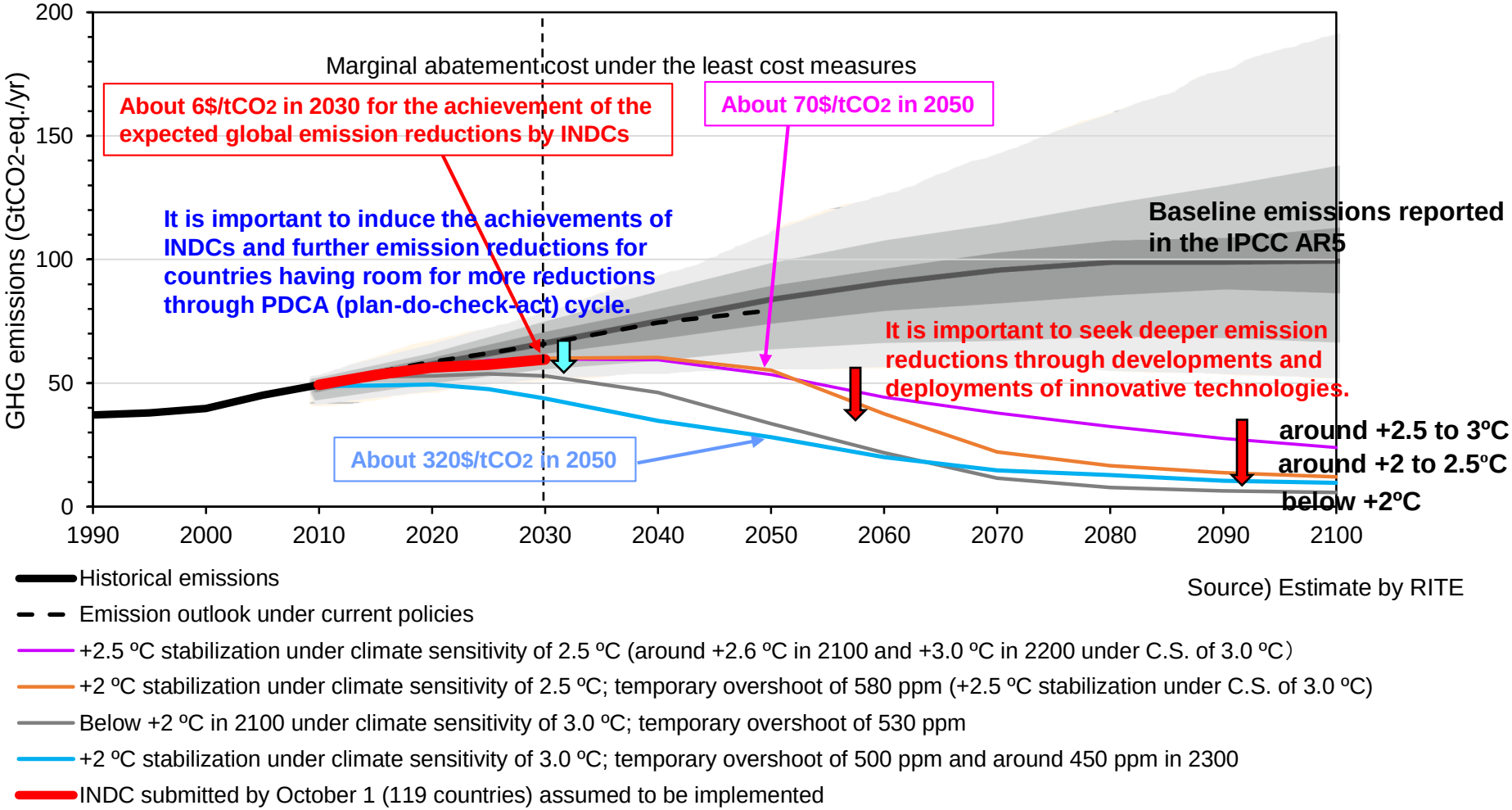
http://unfccc.int/focus/indc_portal/items/9240.php
Based on the submissions made on 2015, October 1st, by 119 countries

56.7 (53.1～58.6) GtCO2eq



P1: immediately reduced from 2010 level to +2 °C target (>66% achievability)
P2: reduced after Cancun Pledge to +2 °C target (>66% achievability)
P3: reduced after 2030 NDCs to +2 °C target
There are wide gap between P2 (also P1) and P3. However, there remains pathways to reach +2 °C target (>50%) after 2030 NDCs by deepening emission reductions thereafter.

Expected global GHG emissions of the aggregated INDCs and the corresponding emission pathways up to 2100 toward +2 °C goal

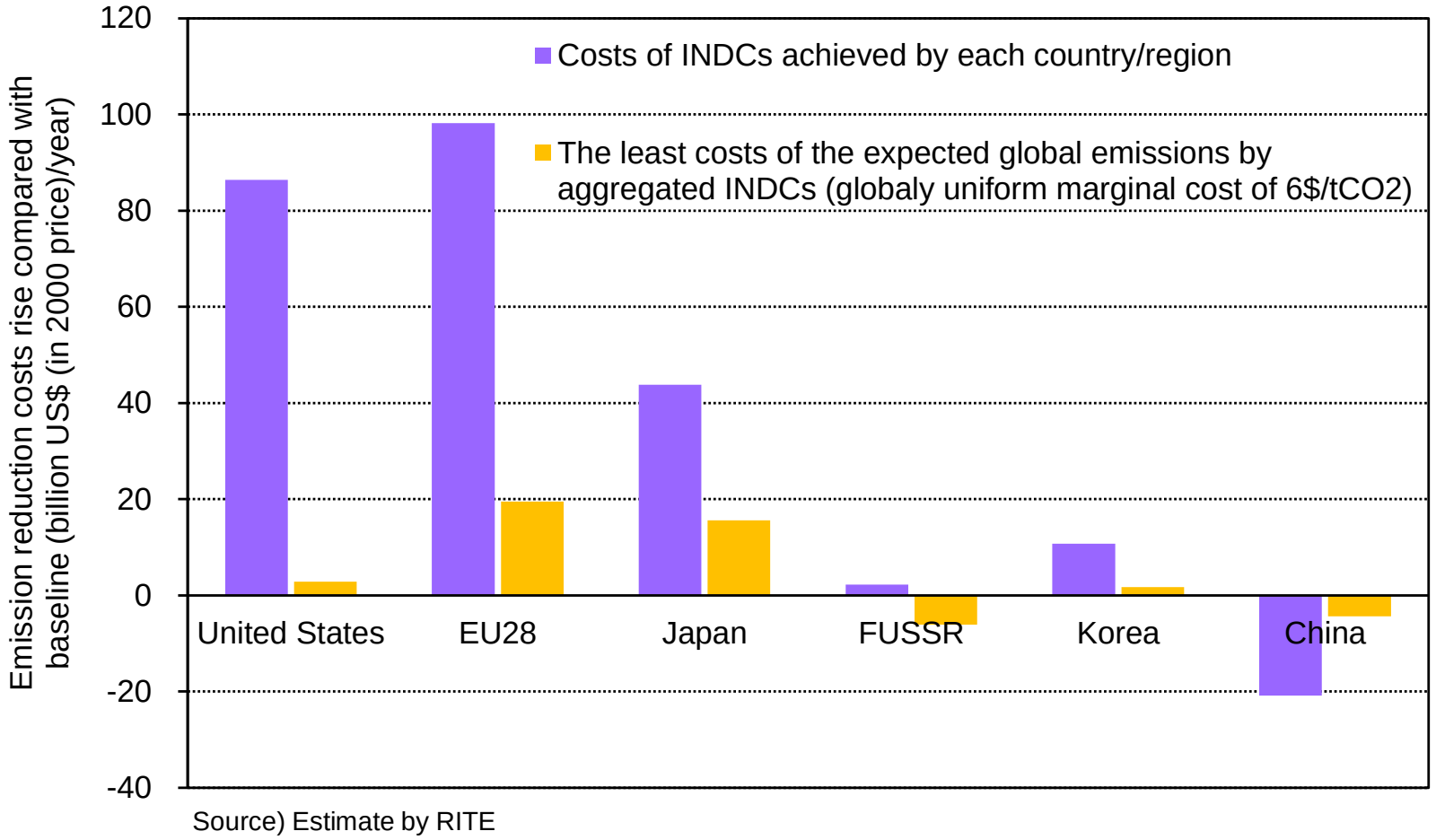


Source) Estimate by RITE

- The expected global GHG emission in 2030 is about 59.5 GtCO2eq. when all the submitted INDCs are successfully achieved. Emissions reductions from the baseline are estimated to be about 6.4 GtCO2eq, in which about 0.5 GtCO2eq reductions are offset due to carbon leakages from nations with INDCs of high marginal abatement costs to those with zero or low costs through induced lower fossil fuel prices.

- The expected temperature change in 2100 is +2 to +3 °C from preindustrial levels. The range depends on the uncertainties of climate sensitivity, and on future deep emission reductions through developments and deployments of innovative technologies.

Emission reduction costs by INDCs
- Comparison between the individual achievement by each country/region and the global least cost -



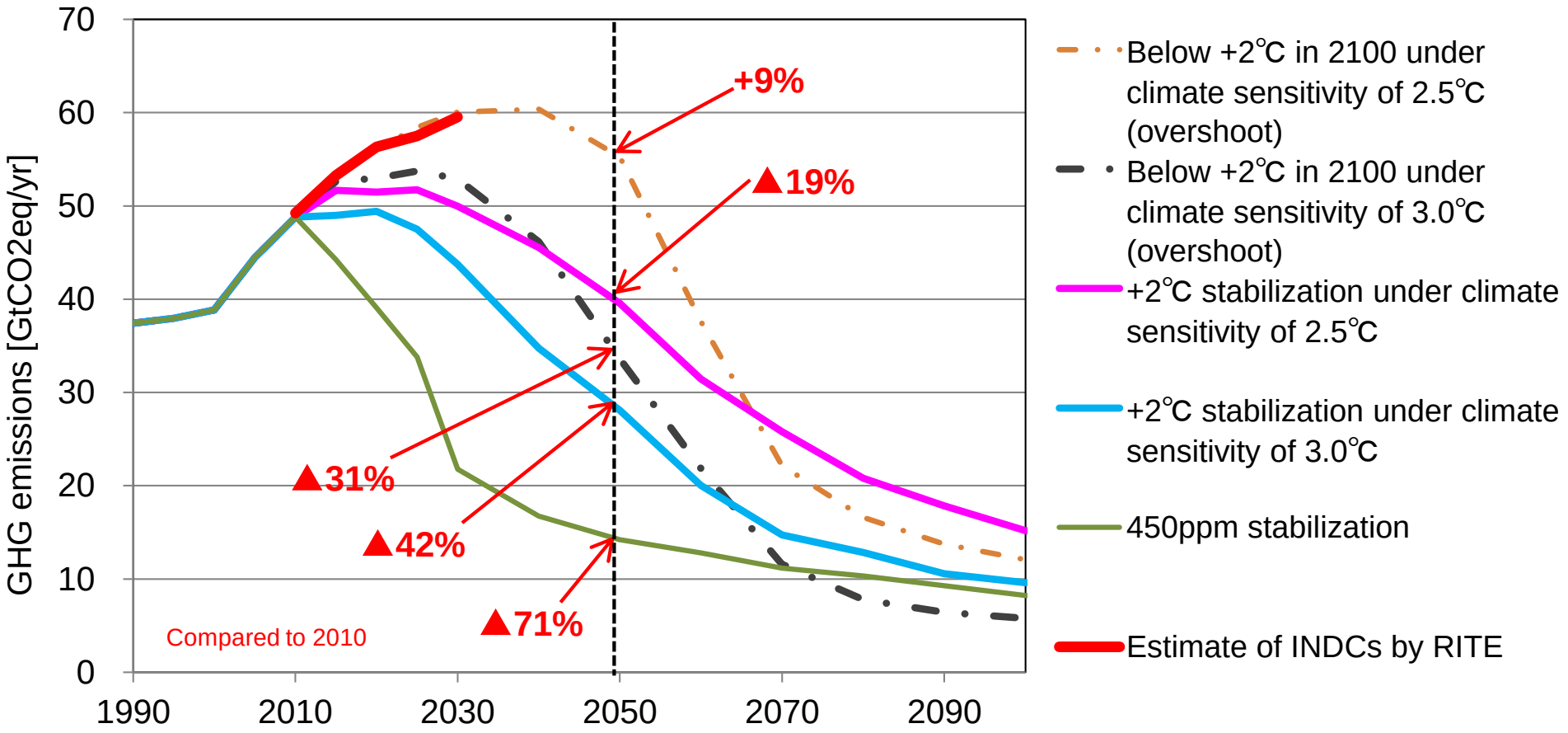
Source) Estimate by RITE

- Due to large differences in marginal abatement costs across countries, we observe on the one hand severe economic impacts for some countries with high marginal abatement costs for the INDCs, and on the other hand positive impacts for countries with zero or low marginal abatement costs.
- In reality, achieving the INDCs could require much higher costs per country than the global least-cost emission reduction as the IPCC scenarios show.

Atmospheric GHG Concentration, Emission Reduction in 2050, and Expected Temperature Increase

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
<430	Only a limited number of individual model studies have explored levels below 430 ppm CO2eq						
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%

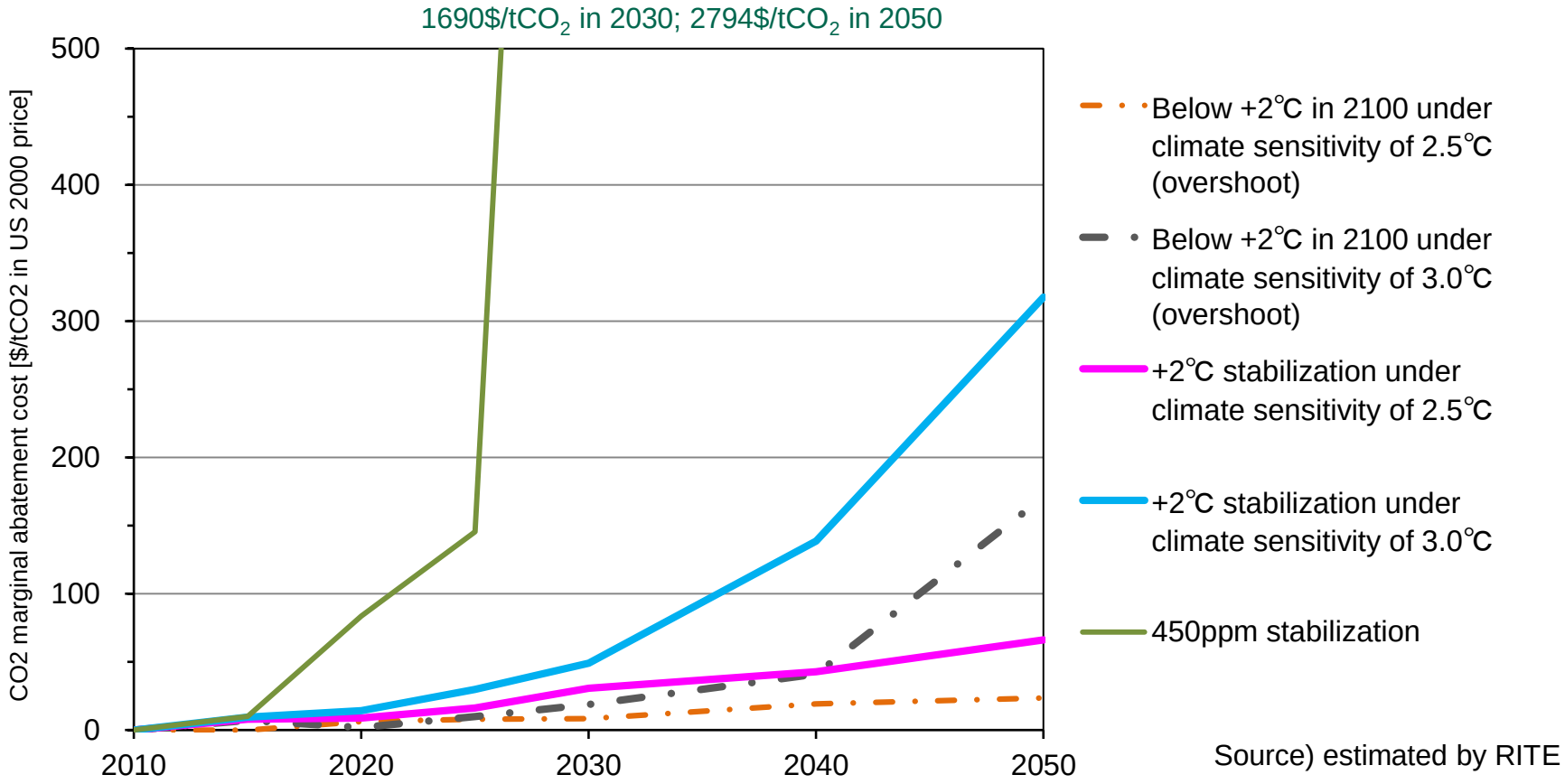
GHG Emission Pathways for Below +2 °C



Source) estimated by RITE using MAGICC and DNE21+

- The emission pathways are very different even for a certain level of temperature target, i.e., below 2 °C, depending on the assumptions of the target year, the achievability, climate sensitivity uncertainties etc.
- The required emission reduction measures also vary according to these uncertainties even for the political decisions of the temperature below 2 °C.

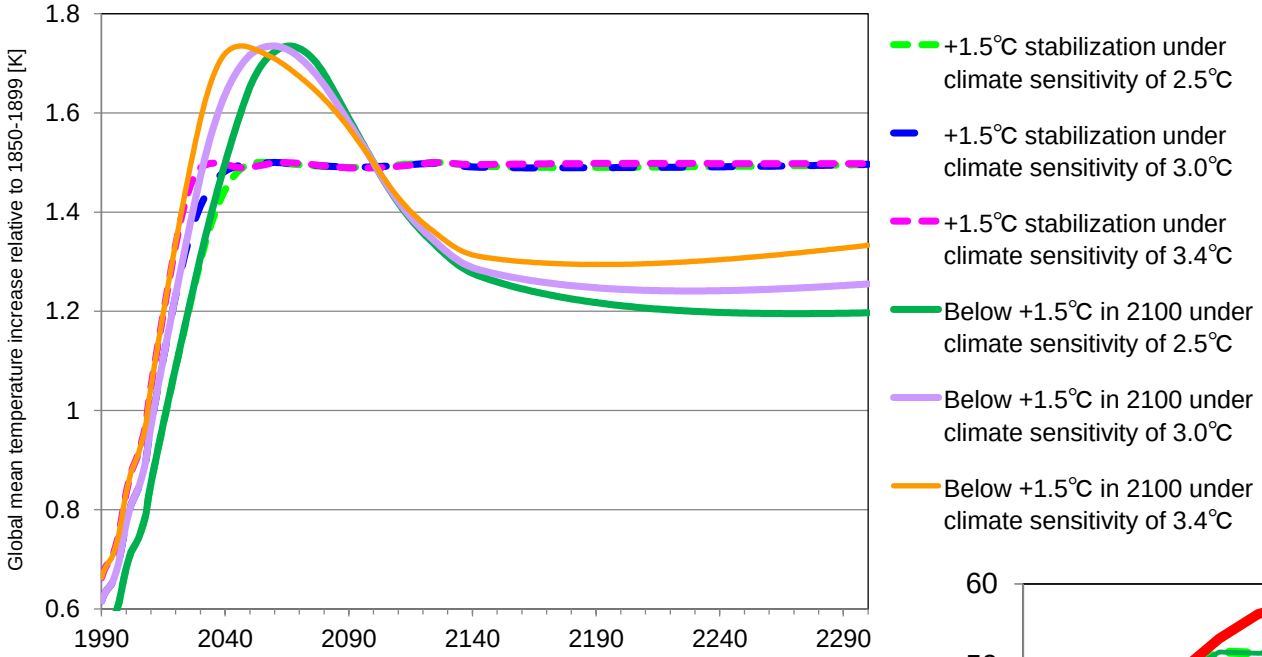
CO_2 Marginal Abatement Costs for Below +2 °C



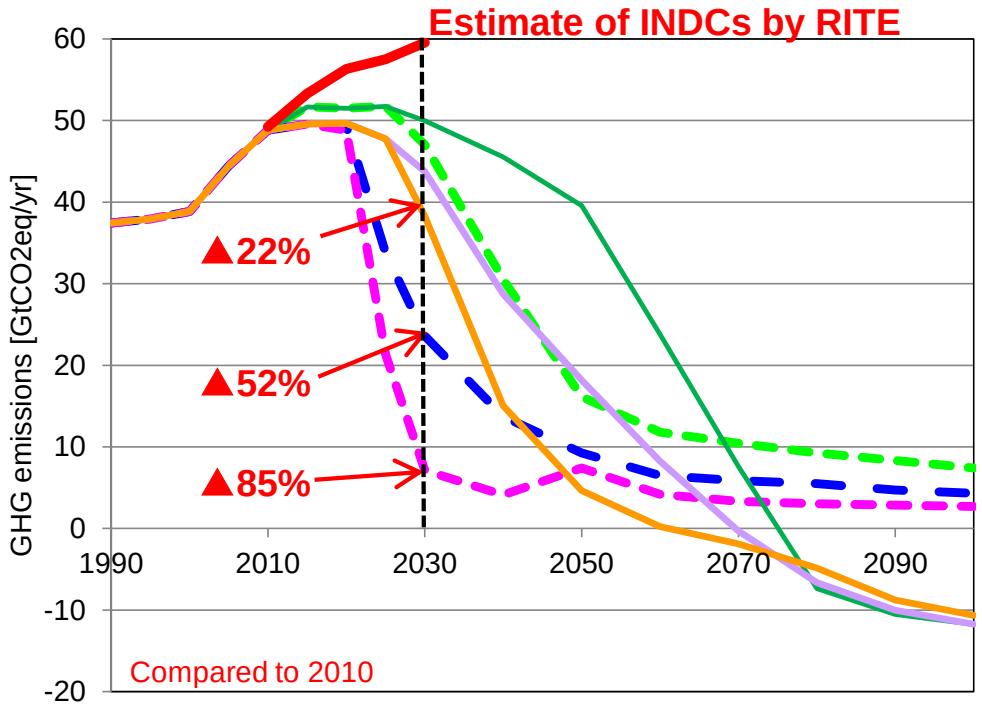
Source) estimated by RITE

- According to the analysis by DNE21+, the mitigation measures with over 1000 $/tCO2 are required after 2030 for the stabilization at 450 ppm CO2-eq even if the least global cost measures (the equal marginal abatement costs) are implemented.
- The mitigation measures with over 300$/tCO2 are required even for the 2.0 °C stabilization under climate sensitivity of 3.0 °C.
- The mitigation costs for below 2 °C with overshoot and climate sensitivity of 2.5 °C are much smaller than those for 450 ppm CO2-eq and +2 °C stabilization under climate sensitivity of 3.0 °C.

GHG Emission Pathways for Below +1.5 °C



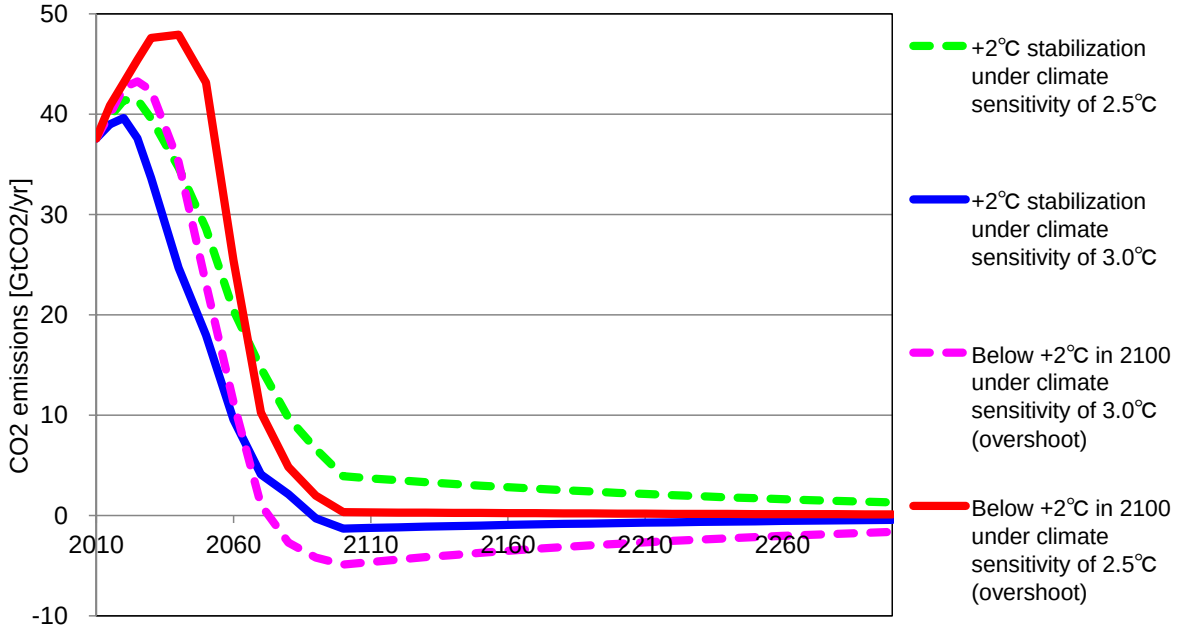
Source) estimated by RITE using MAGICC



- The global GHG emissions in 2030 should be reduced by 85% and 52% relative to 2010 for below 1.5 °C with over 66% achievability (corresponding to climate sensitivity of about 3.4 °C) and over 50% achievability.
- The emissions in 2030 should be reduced by 22% for below 1.5 °C in 2100 with overshoot with over 66% achievability.

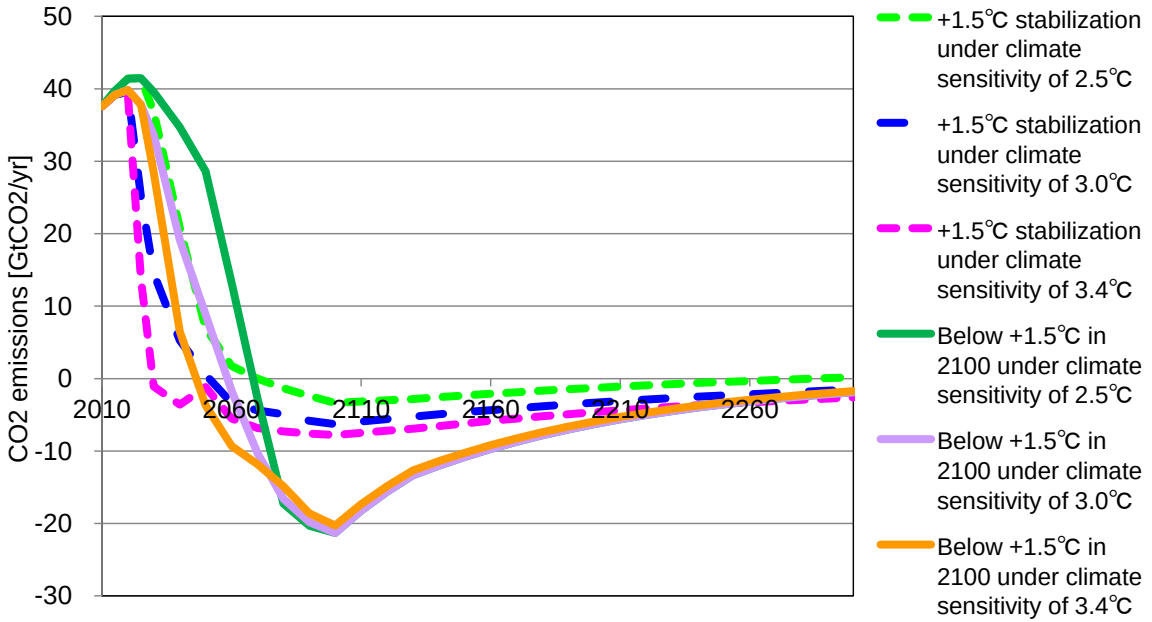
CO_2 Emission Pathways for Below +2 and +1.5 °C

Below +2 °C



Source) estimated by RITE

Below +1.5 °C



In both temperature targets CO_2 emissions in a far future are almost zero, while these trajectories are very different.

Discussions on the Long-term Goals including 2 °C target (1/2)

David Victor and Charles F. Kennel, Nature, October 2014

- Politically and scientifically, the 2 °C goal is wrong-headed. Politically, it has allowed some governments to pretend that they are taking serious action to mitigate global warming, when in reality they have achieved almost nothing.
- A single index of climate-change risk would be wonderful. Such a thing, however, cannot exist. Instead, a set of indicators is needed to gauge the varied stresses that humans are placing on the climate system and their possible impacts. A global goal for average concentrations in 2030 or 2050 must be agreed on and translated into specific emissions and policy efforts, updated periodically.

Oliver Geden（SWP）, Nature, May 2015

- The fourth assessment of the IPCC stated that emissions must peak by 2015 to stay within 2 °C of warming; yet the fifth IPCC report, released last year, refers to 2030 emissions levels higher than today's that are still compatible with this limit, albeit with annual emissions-reduction rates of 6%.
- Policy-makers are delighted to hear that despite 20 years of mounting emissions, the 2 °C target is still theoretically within reach, ignoring the fine print of the IPCC reports.
- The climate policy mantra — that time is running out for 2 °C but we can still make it if we act now — is a scientific nonsense. Advisers who shy away from saying so squander their scientific reputations and public trust in climate research.

Discussions on the Long-term Goals including 2 °C target (2/2)

Jeff Tollefson, Nature, November 2015

- Climate modellers have developed dozens of rosy 2 °C scenarios over several years, and these fed into the latest assessment by the IPCC. The panel seeks to be policy-neutral and has never formally endorsed the 2 °C target, but its official message, delivered was clear: the goal is ambitious but achievable. Despite broad agreement that the emissions-reduction commitments that countries have offered up so far are insufficient, policymakers continue to talk about bending the emissions curve downwards to remain on the path to 2 °C.
- The 2 °C scenarios that define that path seem so optimistic and detached from current political realities. In particular, some researchers have questioned the viability of large-scale bioenergy use with carbon capture and storage (CCS), on which many models now rely as a relatively cheap way to provide substantial negative emissions.

Knutti, R.（ETH Zürich）et al. , Nature Geoscience, January 2016

- The 2 °C warming target is perceived as a universally accepted goal, identified by scientists as a safe limit that avoids dangerous climate change. This perception is incorrect: no scientific assessment has clearly justified or defended the 2 °C target as a safe level of warming. Global temperature is the best climate target quantity, but it is unclear what level can be considered safe.
- A meaningful target for limiting warming must be clearly related to what should be achieved. In addition (i) it needs to be observed with sufficient accuracy, both today and back in the past, (ii) a robust understanding is required of how humans have affected the level of warming so far and how we can control it, and (iii) it should be easy to communicate. Global mean surface temperature largely meets these requirements, but it does not capture ocean acidification, etc.
- Global surface temperature is the indicator that meets most of the requirements for a climate target, but one potential drawback is that the baseline — pre-industrial conditions — is poorly defined.

Conclusions

Managing Long-term Climate Change Risk

- Uncertainties in climate change such as climate sensitivity are still high.
- So far, there are wide gaps between the expected global emissions and the targets of below 2 °C and 1.5 °C from pre-industrial levels.
- On the other hand, international political communities agree with the 2 °C target politically, despite of several critiques claiming that 2 °C is unreal, leading to wrong recognition and wrong policies.
- The following strategy will be a relatively rational when we recognize the real world and real politics:

1) Short- and mid-term emission reductions should be conducted to meet the emission pathways below about 600 ppm CO2eq which still have chances to meet the 2 °C goal.

2) Policies and measures for inducing technology innovations should be enhanced. The achievability of 2 °C target should be increased through these activities, and zero emission societies should be aimed in far future.

3) It seems reasonable that research, at least, on geoengineering approach e.g. SRM should be pursued as well as adaptation, preparing for the case of high climate sensitivity and serious climate damages.

Evaluations of NDCs and Toward an Increase in Effectiveness

- Appropriate review of NDCs are very important in order to increase effectiveness of NDCs and enhance them for deeper emission reductions.
- In the review, multiple and appropriate indicators should be employed for measuring the efforts.
- We evaluated 'emission reduction efforts (degree of ambition)' of INDCs from various aspects, using multiple measurable indicators, for the nations who had submitted them before October 1st, 2015.
- Many indicators of Switzerland, Japan and EU were evaluated to rank high. On the other hand, many indicators of Turkey, Kazakhstan and China were evaluated to rank low. The US was in the middle. However, this result should be interpreted with care because the US's target year is 2025 while many other nations' are 2030.
- For several nations such as China and India, marginal abatement costs were evaluated as zero, meaning their INDCs are to be realized in BAU, according to our socio-economic scenario. Large differences in marginal abatement costs across nations induce carbon leakage, damaging the effectiveness of global emission reduction, and causing a great concern.