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RITE's Evaluations on Emission Reduction Efforts of the INDCs and the Expected Global Emissions

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Main ideas and assessment framework

- We aim here at assessing the equity of emissions reduction efforts in concrete terms.
- As there are differences among countries regarding their abilities to cut emissions, it is very important to take those into account in order to perform a comparative evaluation of each country's emission reduction effort.
- This is not a top-down approach using emission allocation indicators in line with the 2°C target or the 450 ppm target (such an approach would make it difficult to conduct an appropriate evaluation of emission reduction efforts). However, we calculate world total emissions, taking into account all the countries INDCs.
- This analysis is based on the methodology developed in: J. Aldy, B. Pizer, K. Akimoto, Comparing Emissions Mitigation Efforts across Countries (2015).
- 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.

Global Warming Mitigation Assessment Model
(Dynamic New Earth 21+)

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The emission reduction costs in this study were estimated by an energy and global warming mitigation measures DNE21+.

- Energy-related CO2 emission reduction costs can be estimated with consistency.
- 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.
- Interregional trade: coal, crude oil, natural gas, electricity, ethanol, hydrogen, and CO2
- Bottom-up modeling for technologies both in energy supply and demand sides (about 300 specific technologies are modeled.)
- Primary energy: coal, oil, natural gas, hydro, geothermal, wind, photovoltaics, biomass, nuclear power, and ocean energy
- End-use sector: bottom-up modeling for technologies in iron & steel, cement, paper & pulp, chemical, aluminum, and car, and some technologies in residential & commercial sectors, and top-down modelling for sectors without bottom-up modeling by using price elasticity

The detailed assessments by region and by sector are possible with consistency.

The assessments of DNE21+ model are referred in the IPCC AR5, and those have been referred also for the decision processes for climate change mitigation policy in Japanese government.

[Reviewed articles (selected)]

K. Akimoto et al.; Estimates of GHG emission reduction potential by country, sector, and cost, Energy Policy, 38–7, (2010)
K. Akimoto et al.; Assessment of the emission reduction target of halving CO2 emissions by 2050: macro-factors analysis and model analysis under newly developed socio-economic scenarios, Energy Strategy Reviews, 2, 3–4, (2014)

Indicators for emissions reduction efforts evaluation

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.
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)

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	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.

Notes of the assessments of INDCs in this study

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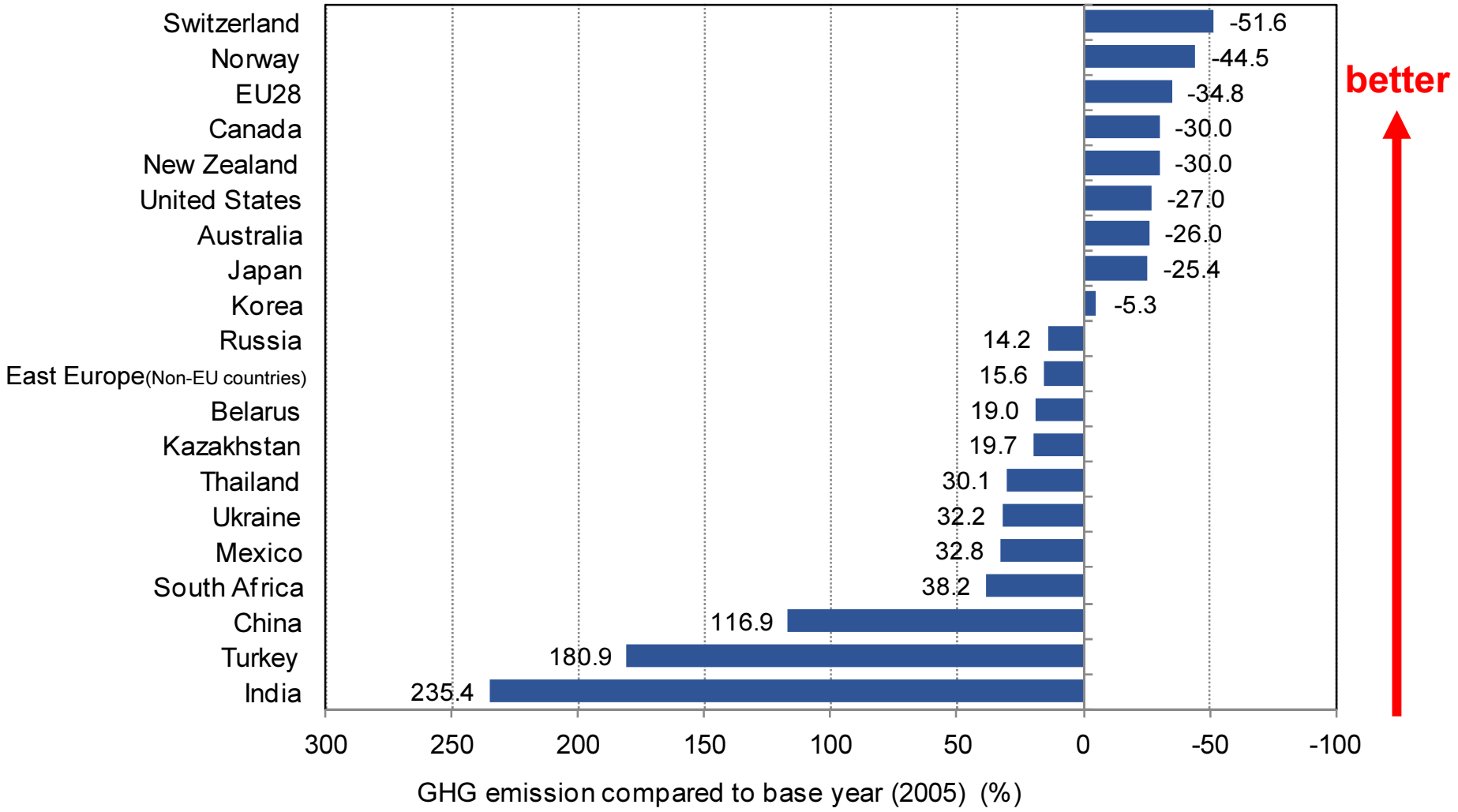
- LULUCF emissions are not taken into account for international comparison of mitigation efforts, because they have large uncertainty and their appropriate evaluation is difficult. (LULUCF emissions are taken into account for the aggregated INDCs evaluation with respect to 2°C target.)
- For the countries with emission reduction targets compared to the base year, the emissions in the target year are calculated based on historical emissions excluding LULUCF. Historical emissions are derived from Greenhouse Gas Inventory Office of Japan for Japan, UNFCCC for other Annex I countries, and IEA for other countries.
- For the countries with emission intensity improvements targets, the emissions in the target year are calculated based on historical emissions and our GDP scenario.
- For the countries with emission reduction ratio targets to BAU, if BAU emissions in target year are stated in their INDCs, the values of INDCs are adopted for calculation of emissions in the target year. If not, their INDCs are not evaluated in the international comparison of mitigation efforts in this study. (For the aggregated INDCs evaluation with respect to 2°C target, their carbon prices are assumed to be zero until 2030.)
- Other countries with policies and actions targets are omitted from this assessment.
- Most of the countries set 2030 as the target year, but the United States and Brazil chose 2025. For these countries, indicators concerning emission reduction efforts in 2025 are evaluated and compared with the other countries' indicators in 2030.
- Evaluation of all of the adopted indicators was carried out for twenty regions.
- For Brazil and Indonesia who are large emitters from LULUCF, only the three indicators (emission reductions compared to base year, emissions per capita, and emissions per GDP) are evaluated including LULUCF.

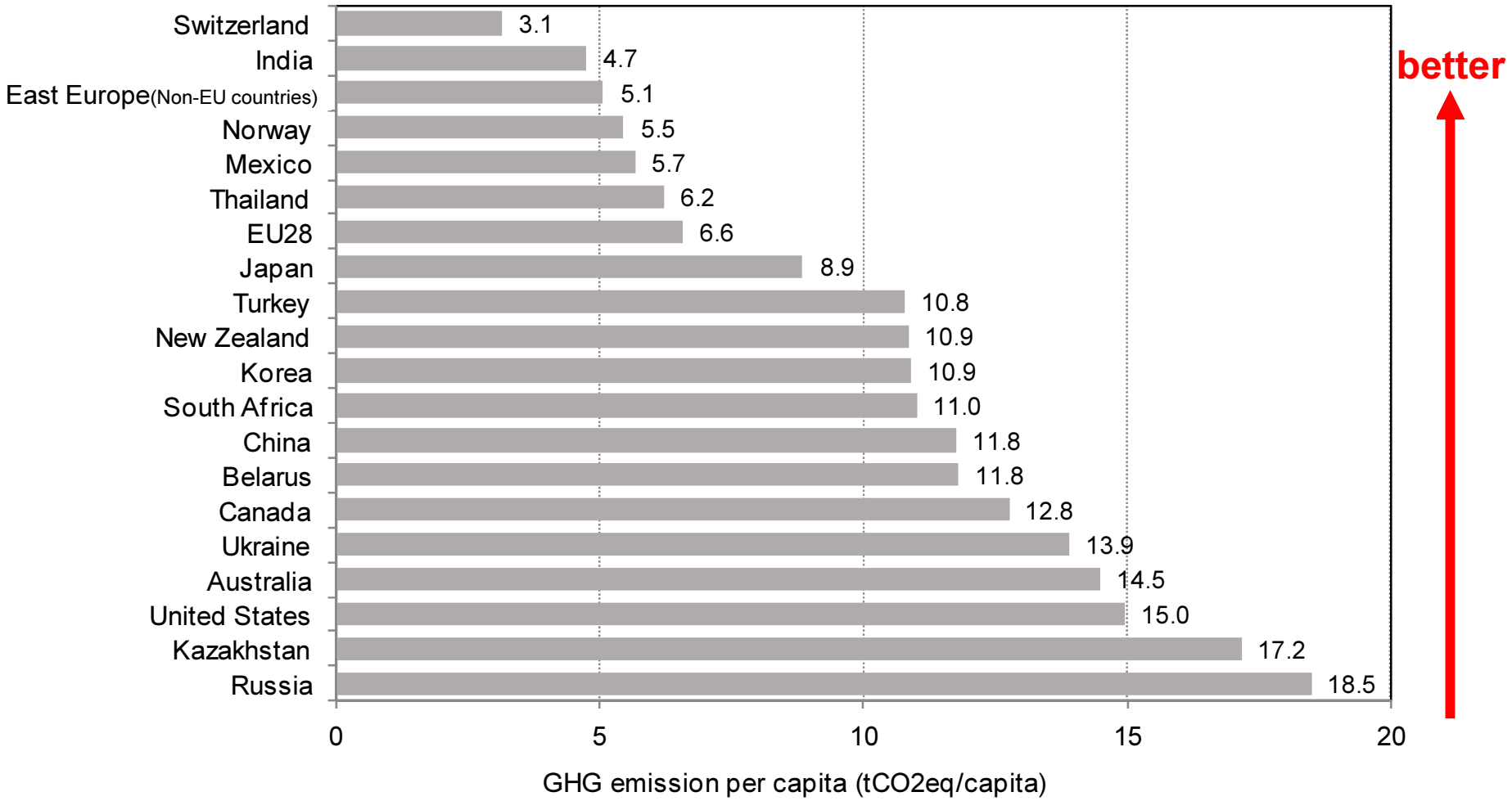
International comparison of emission reduction ratios from the base year of 2005



* 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.

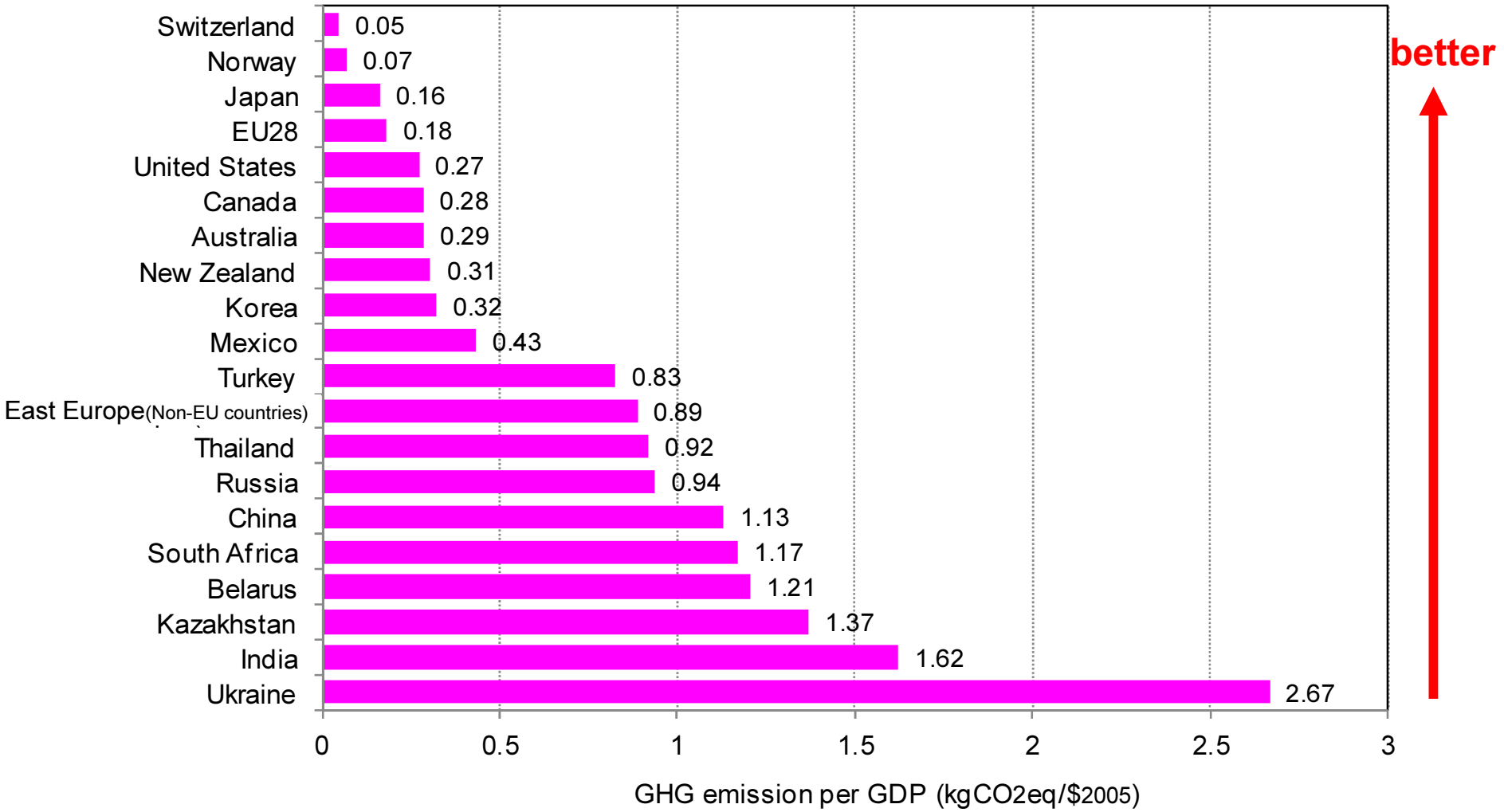
International comparison of GHG emissions per capita



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

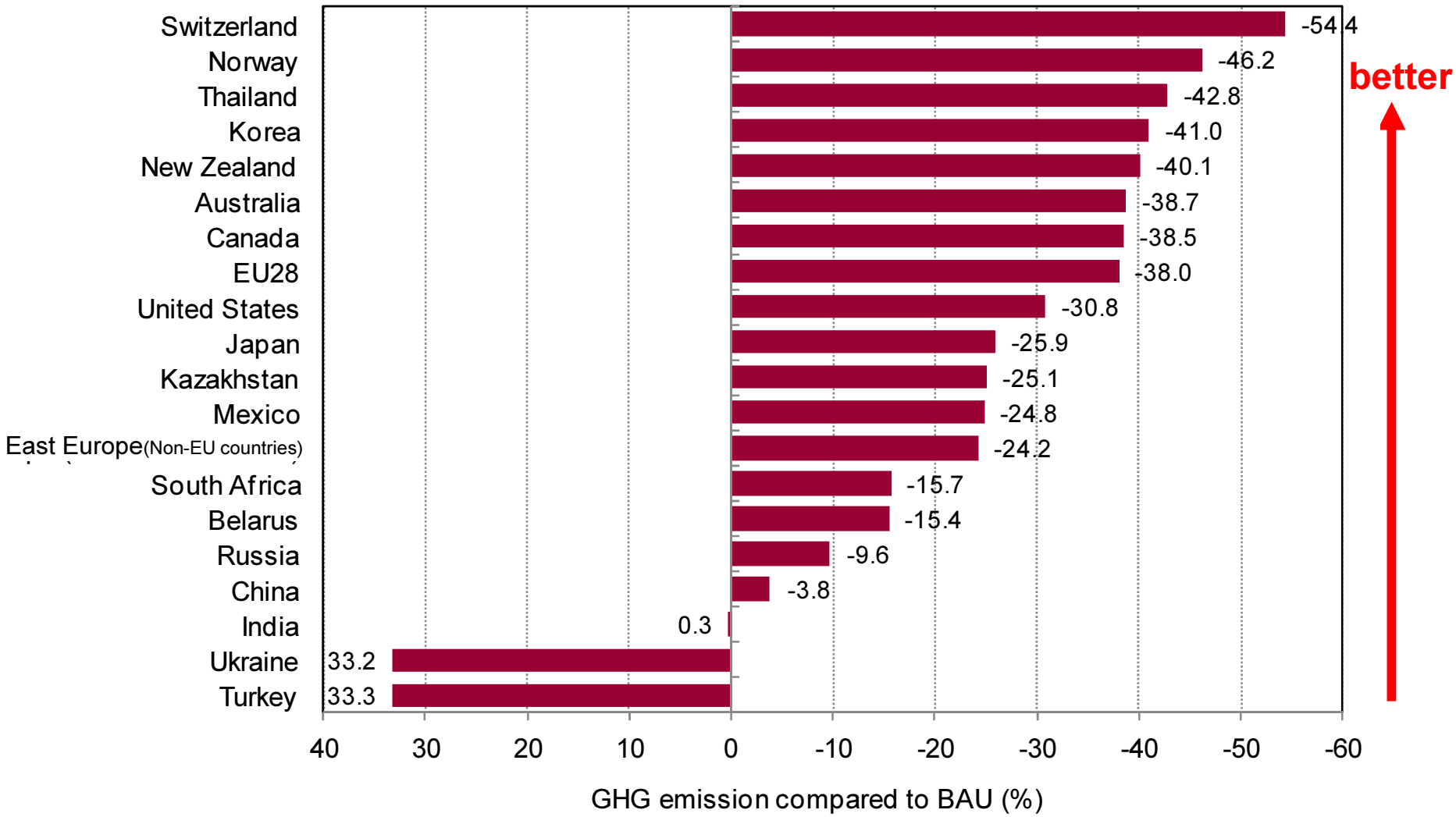
Note) This indicator was employed only for Non-OECD countries and Non-Annex I countries for the integrated ranking.

International comparison of GHG emissions per GDP (MER)



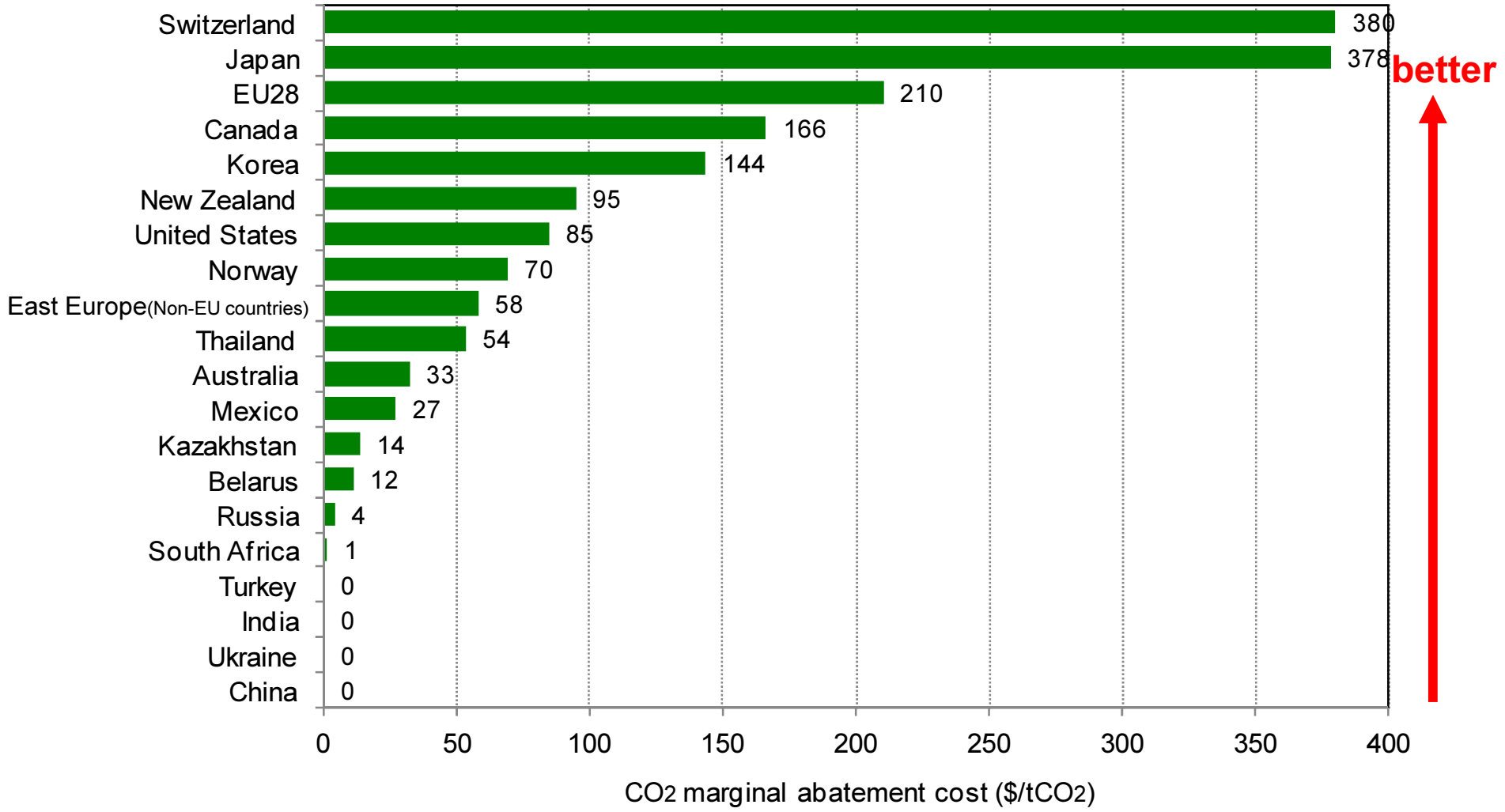
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

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



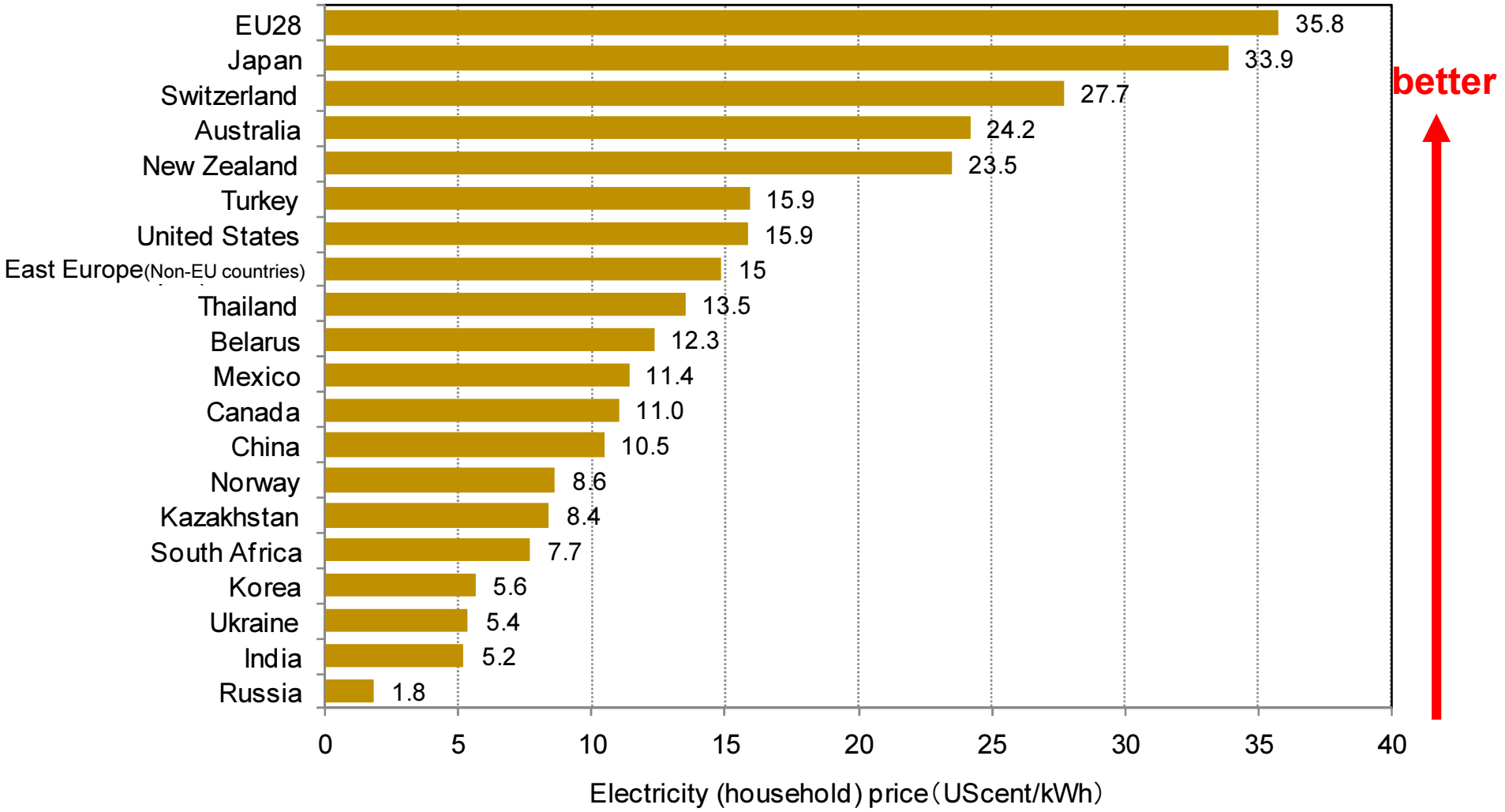
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

International comparison of CO_2 marginal abatement costs



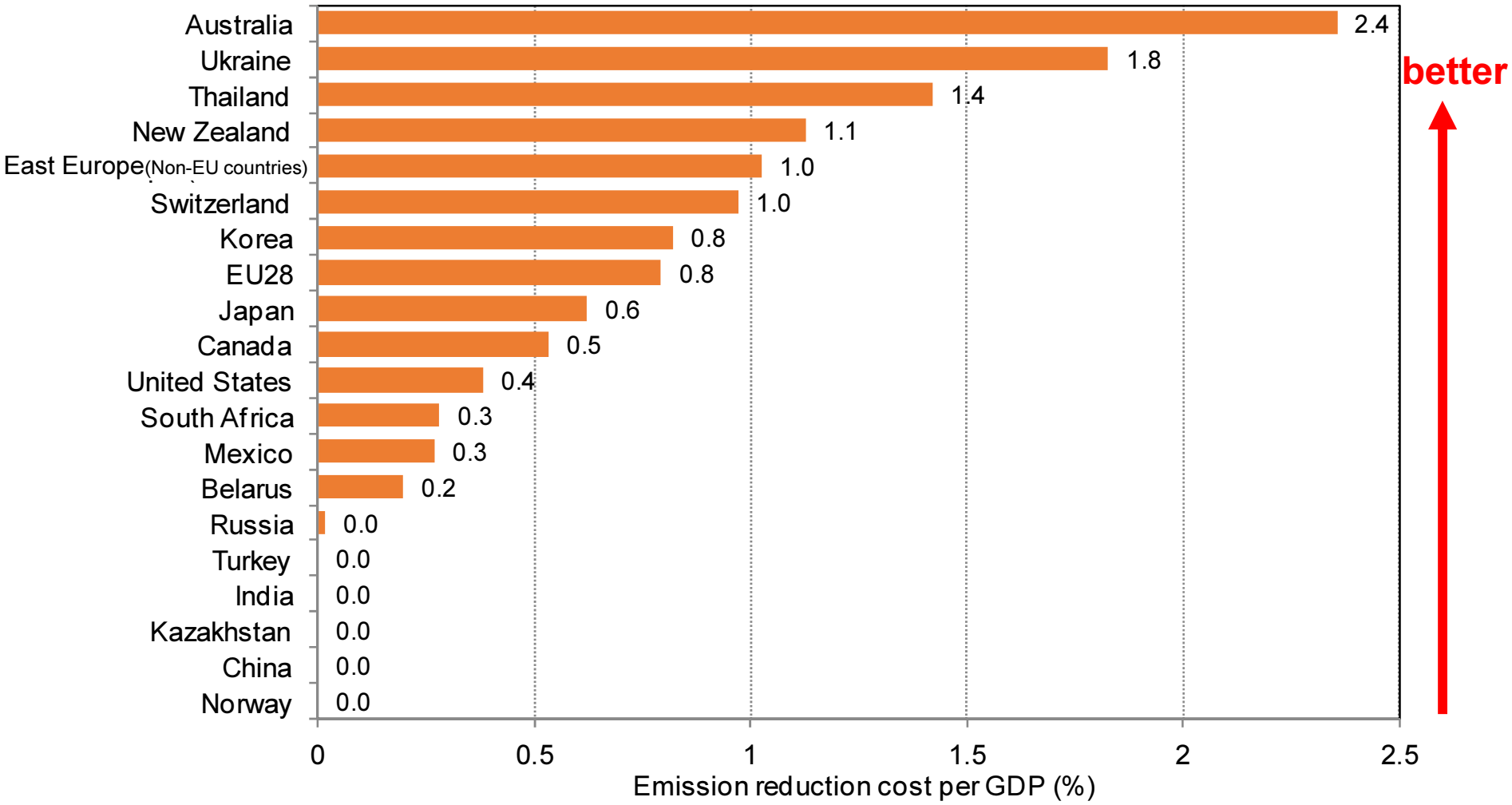
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

International comparison of retail prices of energy (electricity)



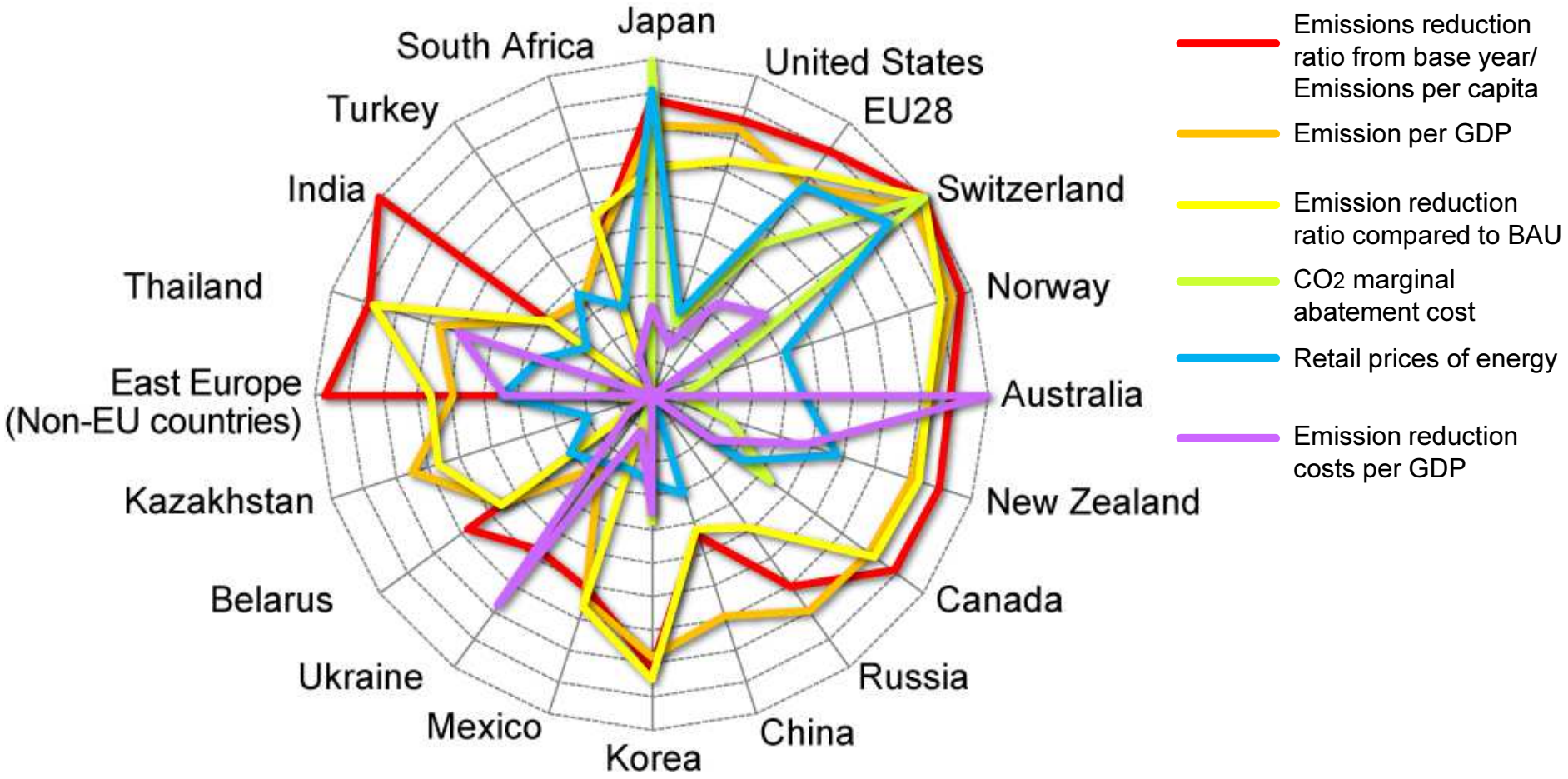
* The average values are shown for the countries submitted the INDC with the upper and lower ranges.

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.

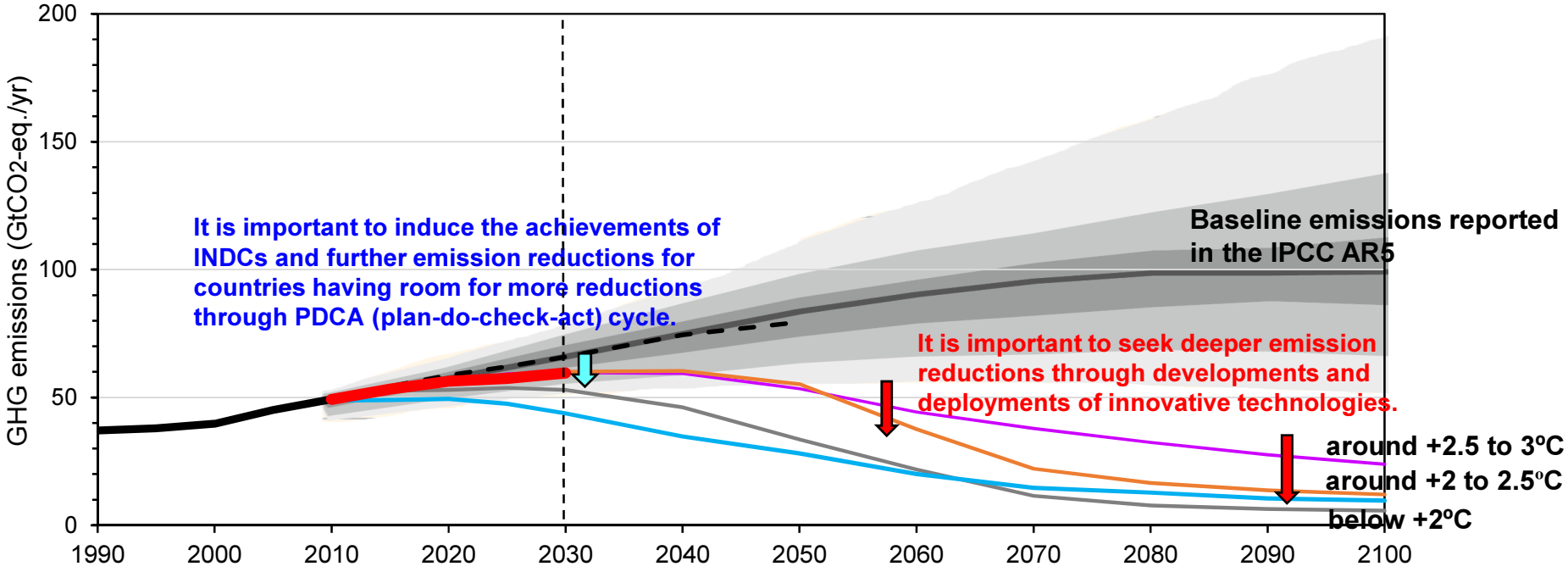
Ranking index of emissions reduction efforts (ambition) of INDCs by indicator



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.

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



Historical emissions

Emission outlook under current policies

+2.5 ºC stabilization under climate sensitivity of 2.5 ºC (around +2.6 ºC in 2100 and +3.0 ºC in 2200 under C.S. of 3.0 ºC)

+2 ºC stabilization under climate sensitivity of 2.5 ºC; temporary overshoot of 580 ppm (+2.5 ºC stabilization under C.S. of 3.0 ºC)

Below +2 ºC in 2100 under climate sensitivity of 3.0 ºC; temporary overshoot of 530 ppm

+2 ºC stabilization under climate sensitivity of 3.0 ºC; temporary overshoot of 500 ppm and around 450 ppm in 2300

INDC submitted by October 1 (119 countries) assumed to be implemented

Source) Estimate by RITE

- The expected global GHG emission in 2030 is about 59.5 $GtCO_2eq$. when all the submitted INDCs are achieved (about 6.4$GtCO_2eq$ reduction from the emission outlook under current policies).
- 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.

Summary: Evaluation of emission reduction 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 (excepting emission reduction costs per GDP) of Switzerland and Japan were evaluated to have high rankings. CO2 marginal abatement cost of Australia is not high, but the emission reduction cost per GDP is large.
- The US was in the middle with respect to many of the indicators. However, this result should be interpreted with care because the US's target year is 2025 while many other nations' are 2030, making the comparison imperfect.
- 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 and the effectiveness of global emission reduction will be damaged and jeopardized, causing a great concern.
- There is no single absolute indicator measuring international fairness and equity, and our study is no exception. Rather, it should be regarded as one of the evaluations that are usefully taken into account in PDCA (Plan-Do-Check-Act) cycle.

Summary: Perspective of global GHG emissions

- Global emissions will be 60 $GtCO_2eq$ in 2030 if all the nations realize their submitted INDCs. (Current emissions are 52–53 $GtCO_2eq$) The 2030 emissions are considered to stay on the pathways of 2–3 °C temperature rise in 2100 relative to the pre-industrial level.
- There are some differences in the estimate of 2030 global emissions among studies. This is due to the differences in expected BAU emissions for nations whose INDCs are expressed in emissions reduction ratio relative to BAU, and BAU GDPs for nations whose INDCs are expressed in emission intensity to GDP. In addition, our study takes into account the carbon leakage effect that is caused when marginal abatement costs are substantially different across nations. (Consequently, emissions increase for nations whose targets are almost equivalent to their BAU values and possibly for those that have not yet submitted INDCs.)
- Estimates of temperature rise vary widely due to wide uncertainty of climate sensitivity (IPCC AR5 evaluates the likely climate sensitivity between 1.5 and 4.5 °C. We estimated the temperature rise for the two climate sensitivity cases of 3.0 and 2.5 °C.) and also assuming innovative technology development and diffusion and large emissions reduction correspondingly brought about by them in the latter half of the century.