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

Systems Analysis Group

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Executive Summary

Overview of the evaluation method

- This analysis targets **the countries that had submitted their INDCs by October 1st, 2015.** 119 countries had done so by then, **covering about 88%** of 2010 world emissions.
- Concretely, the survey aims at assessing the fairness and equity of countries' emissions reduction efforts. Since there are undeniable disparities between countries regarding their ability to cut emissions, it is crucial to take that into account in order to perform a relevant evaluation of each country's emissions reduction effort.
- However, there is no unique indicator to rate the fairness and equity of emissions reduction efforts. **We thus need to adopt a multifaceted approach using a number of relevant indicators.** This analysis is based on the following indicators: **emissions reduction ratio compared to base year, emissions per capita, CO2 intensity, emissions reduction ratio compared to BAU, CO2 marginal abatement cost (carbon price), retail prices of energy (electricity, gas, gasoline, diesel), emission reduction costs per GDP.**
- Then, for each indicator, we apply the value 1.0 to the country with the best performance, and 0.0 to the country with the lowest performance. **We thus realize a ranking of countries' emissions reduction efforts (degree of ambition).**

Note: the model gives estimates of emissions reduction costs for 22 countries or regions; among them, CO2 emissions from LULUCF are particularly high for Brazil and Indonesia, which is why projected emissions reductions are also very important; however, emissions reductions costs for LULUCF are difficult to assess accurately, so we excluded these two countries from our ranking. As a result, 20 countries/regions in total were ranked according to their emissions reduction efforts (degree of ambition). Besides, among these 20 countries, the U.S. were the only one to submit a target for year 2025; it should thus be noted that, although it is difficult to make direct comparisons with others countries' targets in 2030, assessments for the U.S. were conducted as is, without adjusting the U.S. targets' timeline.

Ranking of emissions reduction efforts (ambition) of INDCs

Country	Number of stars	Index of ambition	Evaluation
Switzerland		5.2	Very Excellent
Japan		4.5	Excellent
EU28		4.1	
Australia		4.1	
New Zealand		3.9	Good
Thailand		3.5	
Canada		3.5	
Korea		3.4	
Norway		3.4	
East Europe (Non-EU countries)		3.3	
United States		3.1	
Mexico		2.3	Medium
Belarus		2.2	
Russia		2.0	
India		2.0	
South Africa		1.9	Poor
Ukraine		1.9	
China		1.9	
Kazakhstan		1.6	
Turkey		0.7	

Number of stars indicating ambition (Index 0 to 6.0)

0≥ and <0.25

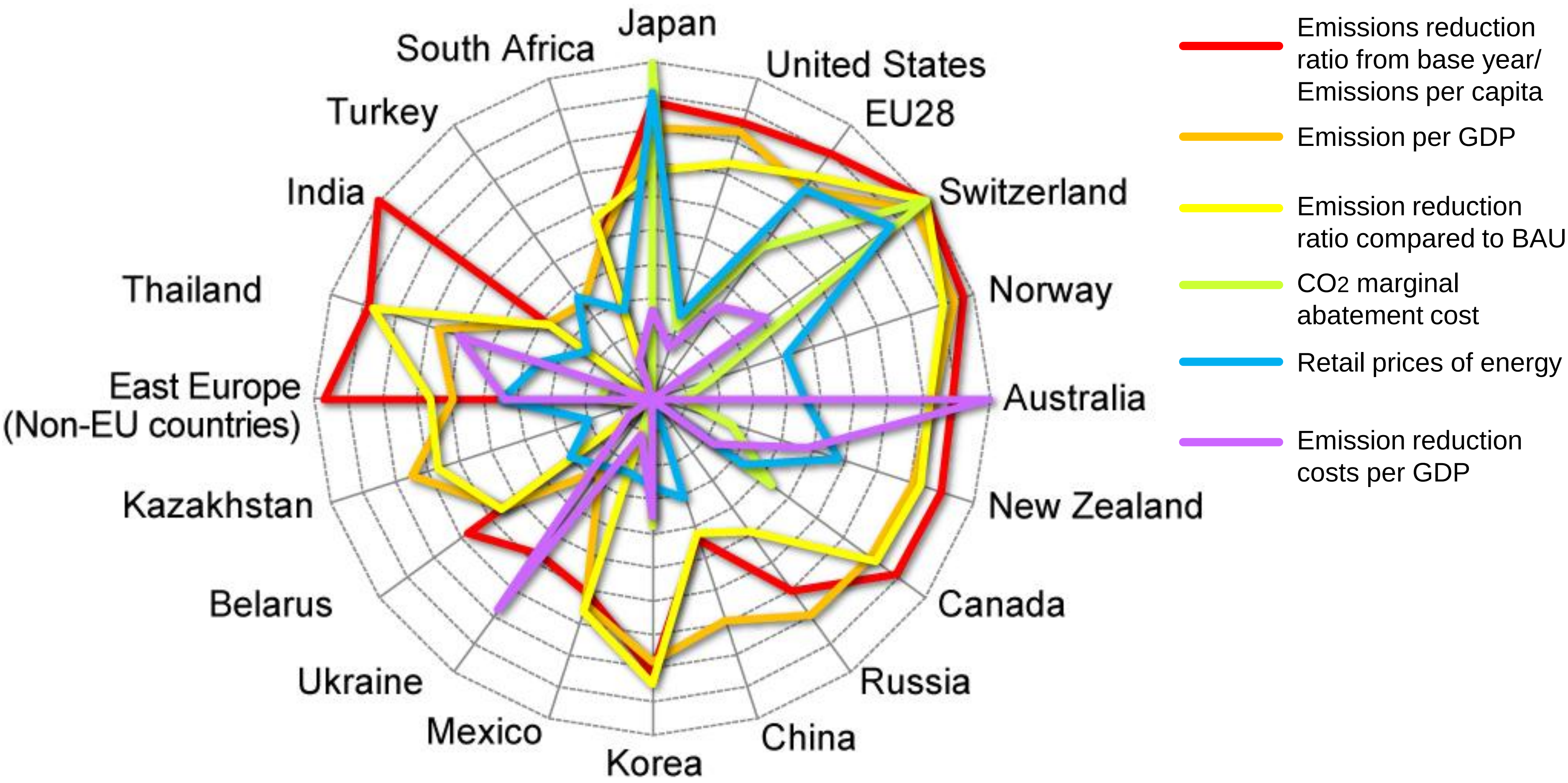
0.25≥ and <0.75

0.75≥ and <1.25

Evaluation in terms of ambition of INDCs

5.0≥ : very excellent
4.0≥ and <5.0 : excellent
3.0≥ and <4.0 : good
2.0≥ and <3.0 : medium
<2.0 : Poor

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

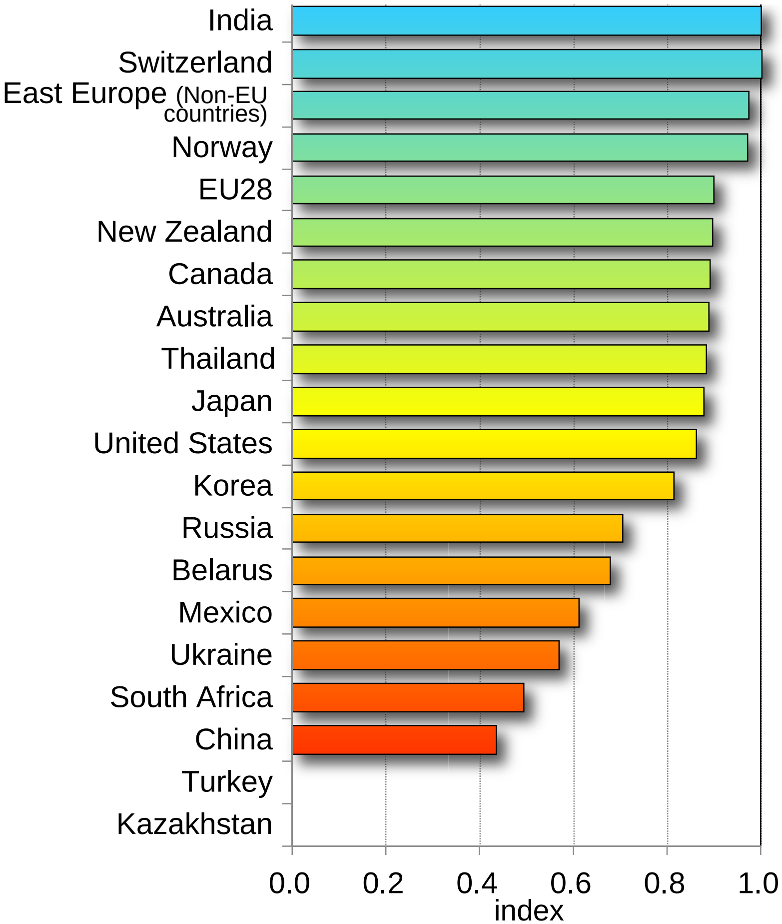


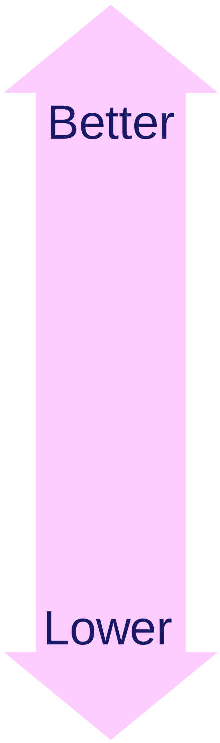
The wider the radar chart is, the greater the emission reduction efforts (ambition) are.

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.

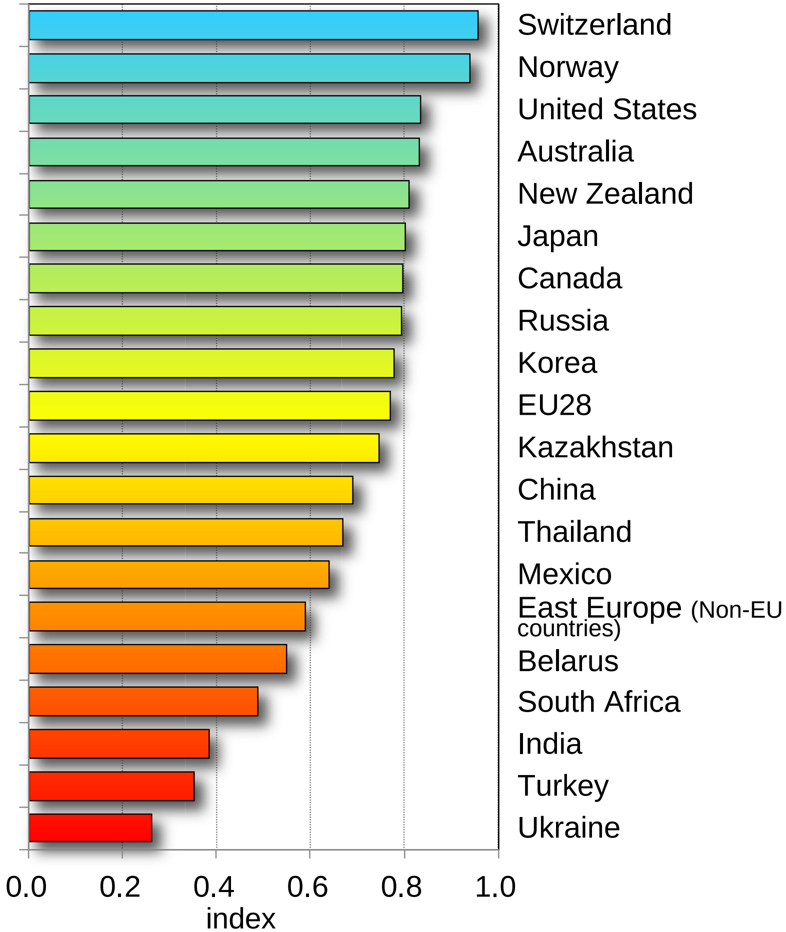
Ranking by indicator (1/3)

Emission reduction ratio from base year (for OECD or Annex), Emissions per capita (for Non-OECD and Non-annex I)



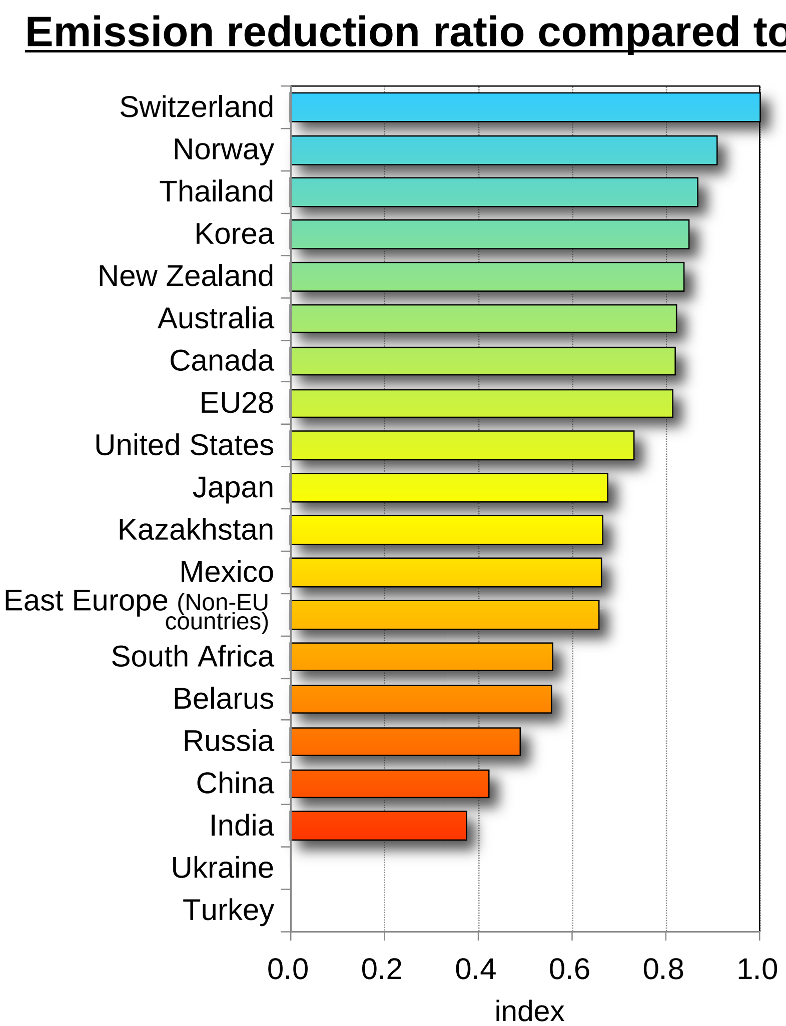


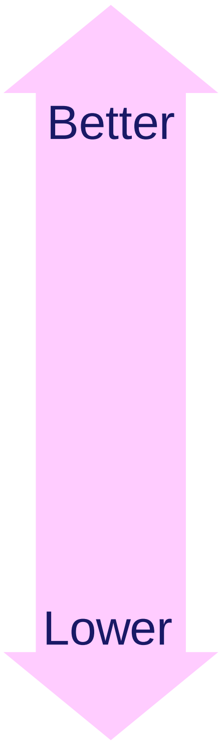
Emissions per GDP (absolute value and improvement rate)

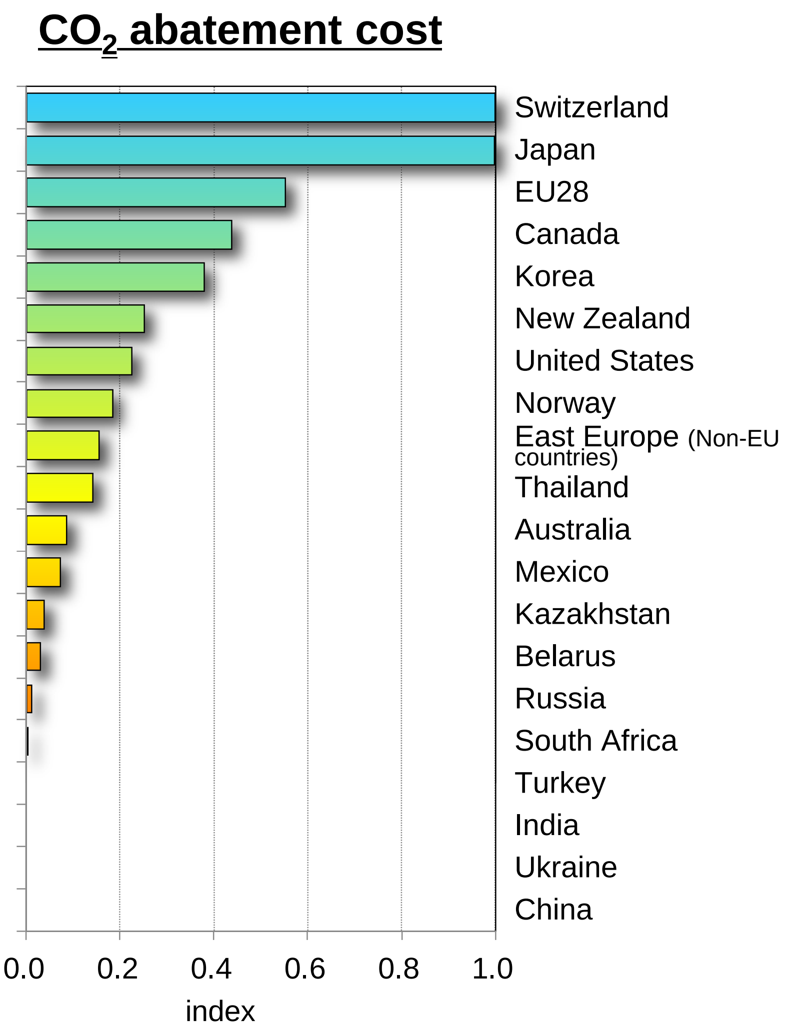


The INDCs of India and Switzerland are evaluated to be good in terms of emissions per capita and emission reduction ratios from 2005 and 2012, respectively. Those of Switzerland and Norway are evaluated to be good in terms of both absolute value and improvement rate of emissions per GDP.

Ranking by indicator (2/3)



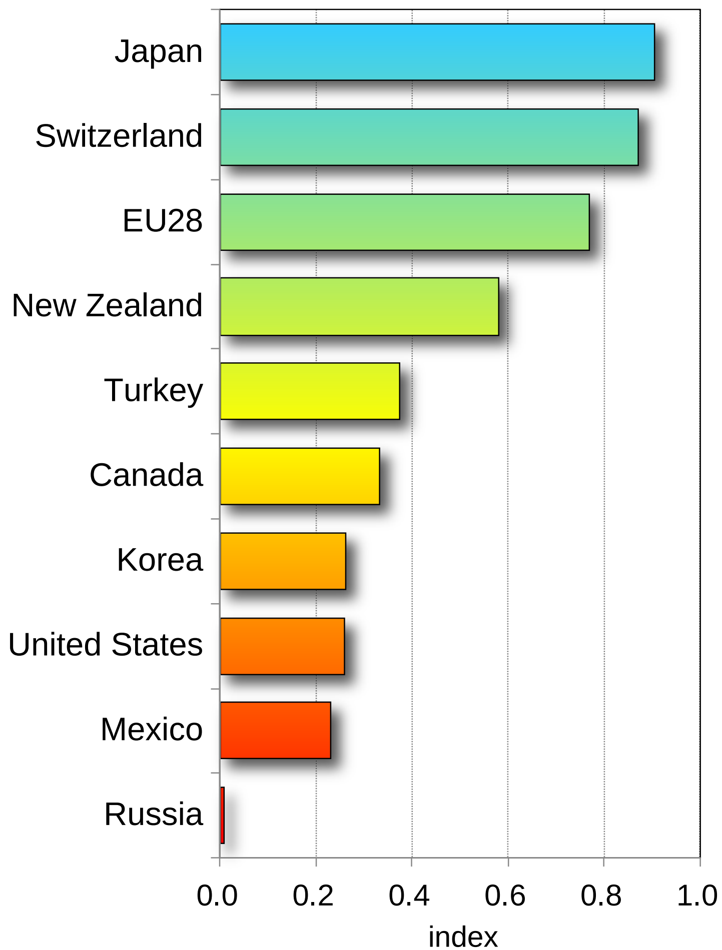


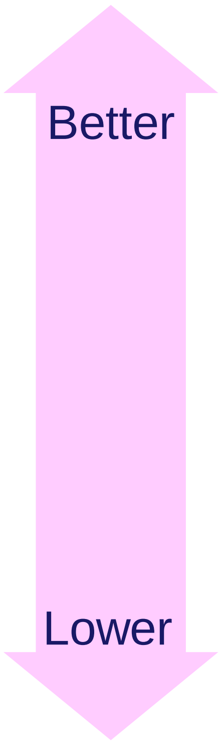


The INDCs of Switzerland and Norway are evaluated to be good in terms of emission reductions ratio from BAU. Those of Switzerland and Japan are evaluated to be good in terms of CO2 marginal abatement cost.

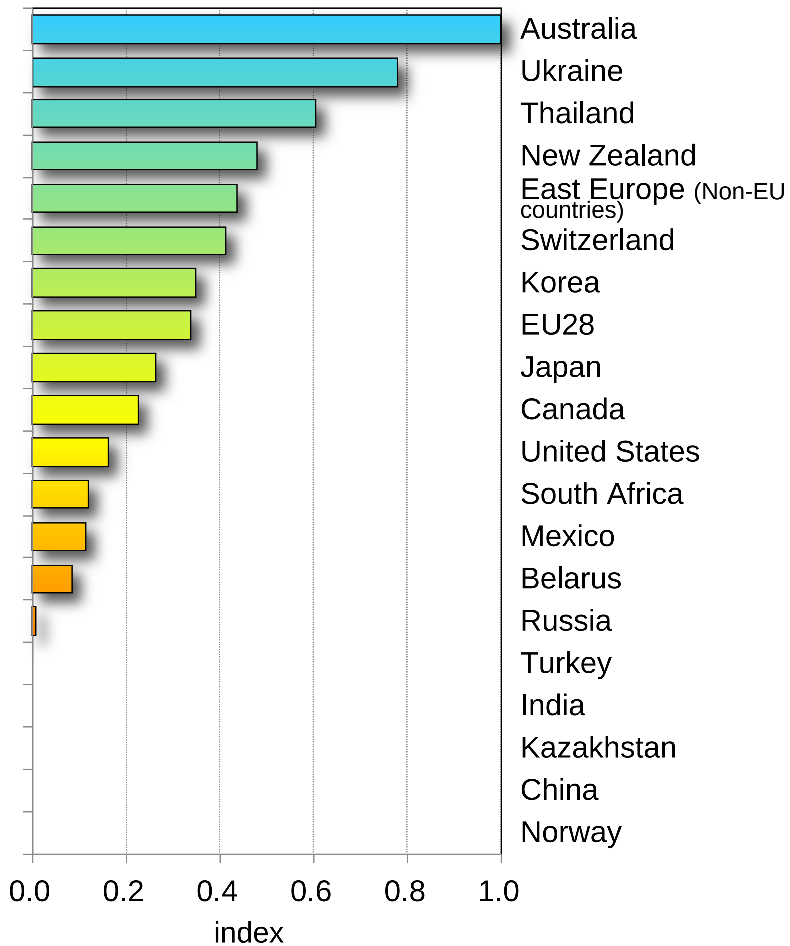
Ranking by indicator (3/3)

Retail prices of energy



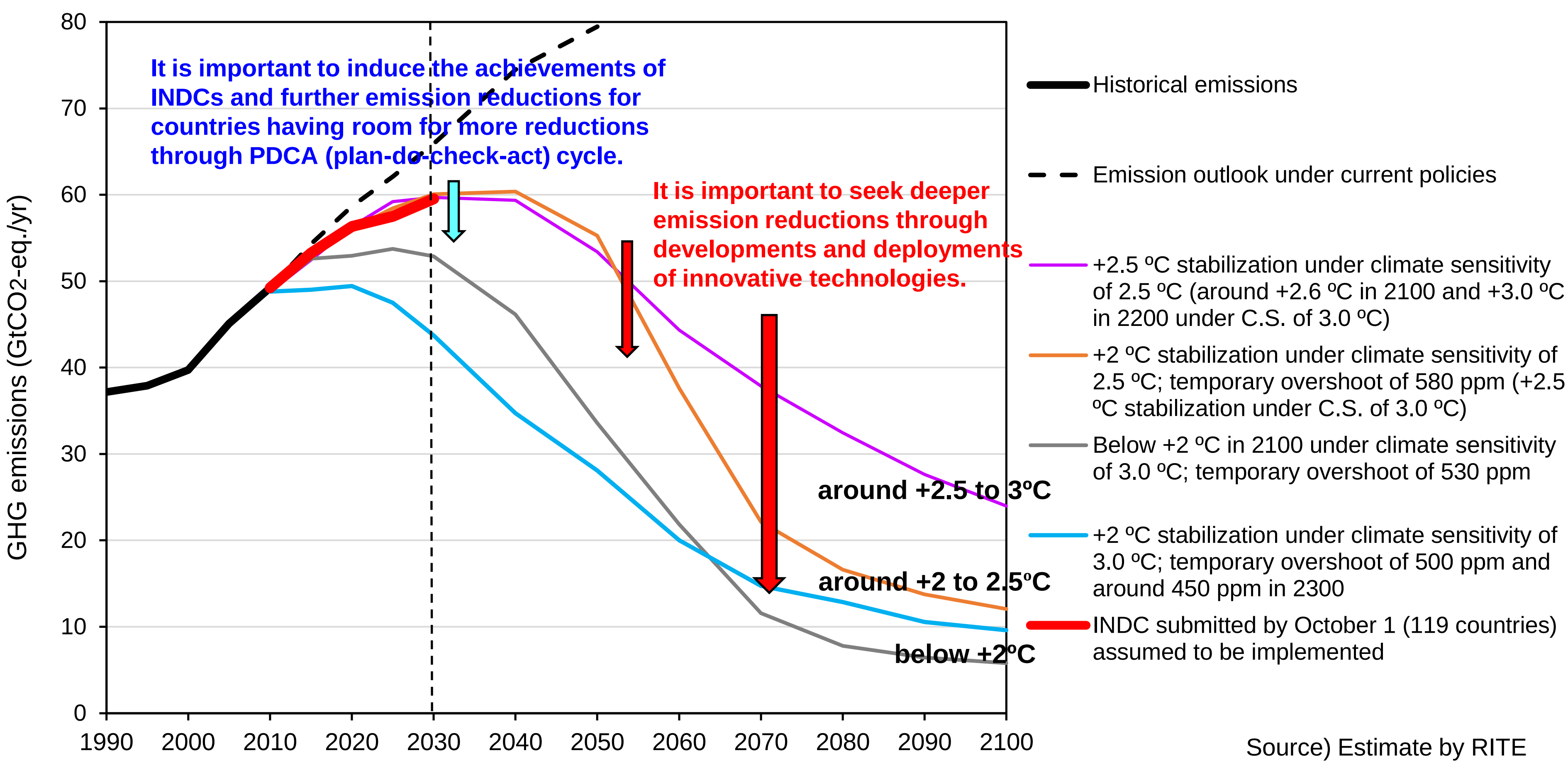


Emission reduction costs per GDP



The INDCs of Japan, Switzerland and EU28 are evaluated to be good in terms of retail prices of energy. Those of Australia and Ukraine are evaluated to be good in terms of emission reduction costs per GDP.

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



Source) Estimate by RITE

- The expected global GHG emission in 2030 is about 59.5 $GtCO_2$eq. when all the submitted INDCs are achieved (about 6.4$GtCO_2$eq 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 sensitivities, and on future deep emission reductions through developments and deployments of innovative and low cost technologies.

Overview of results and the implications

- Based on all the indicators used to assess emission reduction effort **the INDC of Switzerland shows the highest degree of ambition in terms of emission reduction effort.** According to the evaluation, **the 2nd highest is Japan, the 3rd EU.**
- Aggregating to the considered INDC shows that **world emissions of GHG would reach about 60GtCO_2eq in 2030** (against 52-53GtCO_2eq currently), which corresponds to a scenario where global warming reaches +2 °C or +3 °C in 2100 compared to pre-industrial levels.
- Although this may vary according to economic projections, marginal abatement costs for China and India are assessed to be zero (admitted that INDC can be achieved). As there are high disparities between marginal abatement costs from one country to another, there is a risk that such differences will induce carbon leakages, that will themselves hinder the effectiveness of global emissions reductions. In that case, our concern is that actual emissions reductions could be somewhat less effective than assessed in this analysis.
- The implementation of emissions reductions in the second half of the 21st century will be highly dependent on climate sensitivity, as the range for temperature estimation is large, and on the development and diffusion of innovative technologies. Further research on assessing climate sensitivity as well as making progress on innovating technologies are thus both crucial.
- Since achieving INDC target is more and more pressing, it is important for countries that can do so to strengthen their objectives through PDCA (Plan-Do-Check-Act) cycles and its international review system.

Detailed Report

RITE’s Evaluation Methods for Emission Reduction Efforts of INDCs

Principles of measuring the fairness and equity of emissions reduction effort through indicators

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)

Main ideas and assessment framework

- We aim here at assessing the equity of emissions reduction efforts in concrete terms.
- As there are differences between countries regarding their ability to cut emissions, it is very important to take that into account in order to perform a relevant 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 use easily measurable indicators and thus to conduct an appropriate evaluation of emission reduction efforts). However, we calculate world total emissions, taking into account each country's INDC.
- This analysis is based on the methodology developed in: J. Aldy, B. Pizer, K. Akimoto, Comparing Emissions Mitigation Efforts across Countries (2015).
- In this analysis, we go further by scoring the level of each country's emission reduction efforts in order to compare and confront them with one another.
- The next page shows the indicators chosen to assess emissions reduction efforts. For each indicator, we apply the value 1.0 to the country with the best performance, and 0.0 to the country with the lowest performance.
- For the comprehensive evaluation, we affect a weight to each indicator and then calculate the total score.

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 this indicator.	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.

Weighing for the assessment of emissions reduction efforts

	Emissions reduction efforts evaluation method		Weighing for the ranking		
1	**Emissions reduction ratio compared to base year** (only for OECD countries or Annex I countries)	Compared to 2005	1.0	(for OECD countries or Annex I countries)	0.5
		Compared to 2012 (or 2010)			0.5
	Emissions per capita (only for non-OECD countries or non-Annex I countries)	Absolute value		(other)	1.0
2	**CO2 intensity (GHG emissions per GDP)**	Absolute value	1.0	0.5	
		Improvement rate (compared to 2012 or 2010 for emerging countries)		0.5	
3	**Emissions reduction ratio compared to BAU**		1.0		
4	**CO2 marginal abatement cost (carbon price)**		1.0		
5	**Retail prices of energy (electricity, city gas, gasoline, diesel)**	Electricity	1.0	0.333	
		City gas		0.333	
		Gasoline, diesel (weighted average of historical data from 2012 or 2010)		0.333	
6	**Emission reduction costs per GDP**		1.0		

* When there is data missing to calculate one of the indicators, we apply the arithmetic mean of the calculated other indicators for the country and the above-mentioned weighing.

This study presents a comprehensive ranking using 6 categories of indicators with equal weights. However the weighing used here is not unquestionable. It is entirely possible to conduct sensitivity analyses testing different weights, as anyone can use the values presented here for each indicator to conduct their own estimations of total scoring.

Evaluations of Emission Reduction Efforts for the INDCs Submitted by Governments

Evaluated INDCs (1/3)

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.
Many of the Middle-East countries have not submitted their INDCs yet.
A part of the submitted INDCs is summarized as followings.

	2020 (Cancun Agreements)	Post-2020 (INDCs)
Japan	-3.8% compared to 2005*	**-26% by 2030 compared to 2013**
United States	-17% compared to 2005	**-26% to -28% by 2025 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**
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**
Canada	-17% compared to 2005	**-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（2/3）

	2020 (Cancun Agreements)	Post-2020 (INDCs)
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)**
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)**
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**
Albania	—	**-12% by 2030 compared to BAU (CO_2 only)**
The former Yugoslav Republic of Macedonia	—	**-30% by 2030 compared to BAU (Energy-related CO_2 only)**
Republic of Moldova	-25% compared to 1990	**-64% to -67% by 2030 compared to 1990**
Serbia	—	**-9.8% by 2030 compared to 1990**
Thailand	-7 to -20% compared to BAU (Energy and transportation sectors)	**-20% by 2030 compared to BAU**
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**

* Emission reduction target of Mexico includes black carbon.

Evaluated INDCs（3/3）

	2020 (Cancun Agreements)	Post-2020 (INDCs)
Turkey	—	**-21% by 2030 compared to BAU**
South Africa	-34% compared to BAU	**614MtCO_2eq/yr by 2030**
Singapore	-7% to -11% compared to BAU	**To reduce GHG/GDP by -36% by 2030 compared to 2005**
Viet Nam	—	**-8% by 2030 compared to BAU**
Indonesia	-26% compared to BAU	**-29% by 2030 compared to BAU**
Brazil	-36% to -39% compared to BAU	**-37% by 2025 compared to 2005**
Argentina	—	**-15% by 2030 compared to BAU**
Morocco	—	**-13% by 2030 compared to BAU**
Ethiopia	—	**-64% by 2030 compared to BAU**
Kenya	—	**-30% by 2030 compared to BAU**
Democratic Republic of the Congo	—	**-17% by 2030 compared to BAU**
Dominican Republic	—	**-25% by 2030 compared to 2010**

Notes of the assessments of INDCs in this study

- LULUCF emissions are not taken into account for international comparison of mitigation efforts of individual countries, 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 GDP scenario.
- For the countries with emission reduction ratio targets compared to BAU, if BAU emissions in target year are stated in their INDCs, they 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.)
- For other countries (e.g., policies and actions target), treatments of their INDCs are the same as those of the countries which submitted emission reduction targets compared to BAU without statement of BAU emissions in the target year.
- Most of the countries set 2030 as the target year, but 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.

Emission reduction ratios from different base years (1/3)

	Emission reductions relative to different base years			
	1990	2005	2012	2013
Japan: -26% relative to 2013 (by 2030)	-18.0%	-25.4%	-25.0%	<u>-26.0%</u>
United States: -26 to 28% relative to 2005 (<u>by 2025)</u>	-14 to -16%	<u>-26to -28%</u>	-18 to -20%	-18 to -21%
EU28: -40% relative to 1990 (by 2030)	<u>-40%</u>	-35%	-26%	-24%
Switzerland: -50% relative to 1990 (by 2030)	<u>-50%</u>	-52%	-49%	—
Norway: -40% relative to 1990 (by 2030)	<u>-40%</u>	-45%	-43%	—
Australia: -26 to -28% relative to 2005 (by 2030)	-7 to -9%	<u>-26 to -28%</u>	-29 to -31%	—
New Zealand: -30% relative to 2005 (by 2030)	-10%	<u>-30%</u>	-28%	—
Canada: -30% relative to 2005 (by 2030)	-13%	<u>-30%</u>	-26%	—
Russia: -25 to 30% relative to 1990 (by 2030)	<u>-25 to -30%</u>	+18 to +10%	+10 to +3%	—
China: -60 to -65% relative to CO2 emission intensity (by 2030)	+379 to +329%	+129 to +105%	(+71 to +53%)	—
Korea: -37% relative to BAU (by 2030)	+81%	-5%	(-18%)	—

Note) Emissions reductions in parentheses in the column of 2012 are relative to 2010 (no available historical data of 2012)

Emission reduction ratios from different base years (2/3)

	Emission reductions relative to different base years			
	1990	2005	2012	2013
Mexico: -25% relative to BAU (by 2030)	+79%	+33%	(+26%)	—
Ukraine: -40% relative to 1990 (by 2030)	-40%	+32%	+41%	—
Belarus: -28% relative to 1990 (by 2030)	-28%	+19%	+12%	—
Kazakhstan: -15% relative to 1990 (by 2030)	-15%	+20%	(-6%)	—
Albania: -12% relative to BAU (by 2030, CO_2)	+3%	+38%	(+32%)	—
Macedonia: -30% relative to BAU (by 2030, energy related CO2)	+36%	+38%	(+45%)	—
Moldova: -64 to -67% relative to 1990 (by 2030)	-64 to -67%	+8 to -1%	(+9%)	—
Serbia: -9.8% relative to 1990 (by 2030)	-10%	+11%	(+7%)	—
Thailand:-20% relative to BAU (by 2030)	+128%	+30%	(+15%)	—
India: -33 to -35% relative to GHG emission intensity in 2005 (by 2030)	+454% to +437%	+246 to +235%	(+159 to +151%)	—
Turkey: -21% relative to BAU (by 2030)	+393%	+181%	(+130%)	—
South Africa: 614MtCO_2eq/yr (by 2030)	+76%	+38%	(+26%)	—

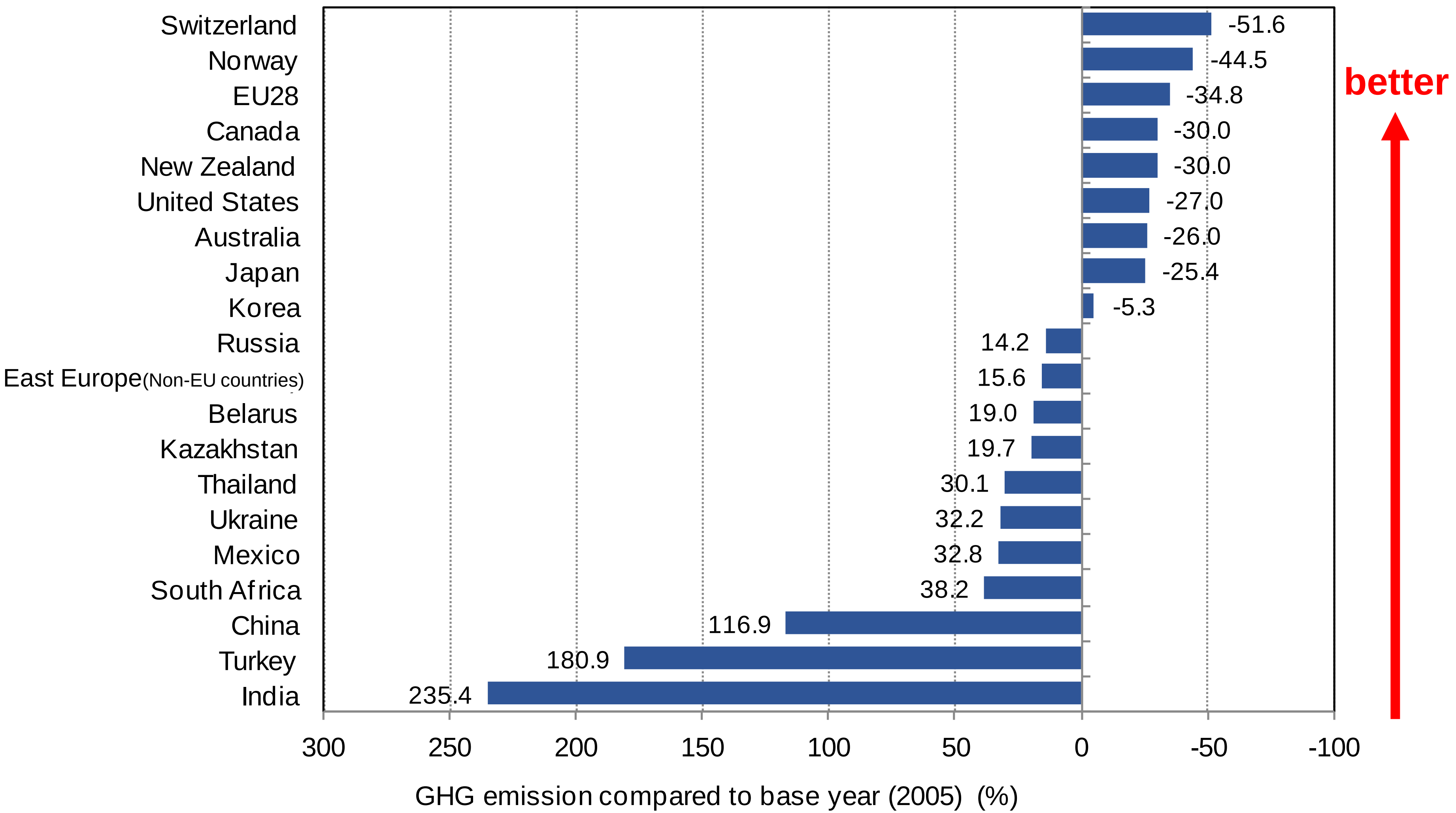
Note) Emissions reductions in parentheses in the column of 2012 are relative to 2010 (no available historical data of 2012)

Emission reduction ratios from different base years (3/3)

	Emissions reductions relative to different base years			
	1990	2005	2012	2013
Singapore: -36% relative to GHG emission intensity in 2005 (by 2030)	+96%	+33%	(+14%)	—
Vietnam: -8% relative to BAU (by 2030)	+687%	+240%	(+143%)	—
Indonesia: -29% relative to BAU (by 2030)	+86%	-28%	(+7%)	—
Brazil: -37% relative to 2005 (by 2025)	+0%	-37%	(+0%)	—
Argentine: -15% relative to BAU (by 2030)	+130%	+84%	(+77%)	—
Morocco: -13% relative to BAU (by 2030)	+305%	+144%	(+115%)	—
Ethiopia: 145MtCO_2eq/yr (by 2030)	+114%	+64%	(+33%)	—
Kenya: -30% relative to BAU (by 2030)	+178%	+123%	(+93%)	—
Democratic Republic of the Congo: -17% relative to BAU (by 2030)	+89%	+213%	(+150%)	—
Dominican Republic: -25% relative to 2010 (by 2030)	+38%	-19%	(-25%)	—

Note) Emissions reductions in parentheses in the column of 2012 are relative to 2010 (no available historical data of 2012)

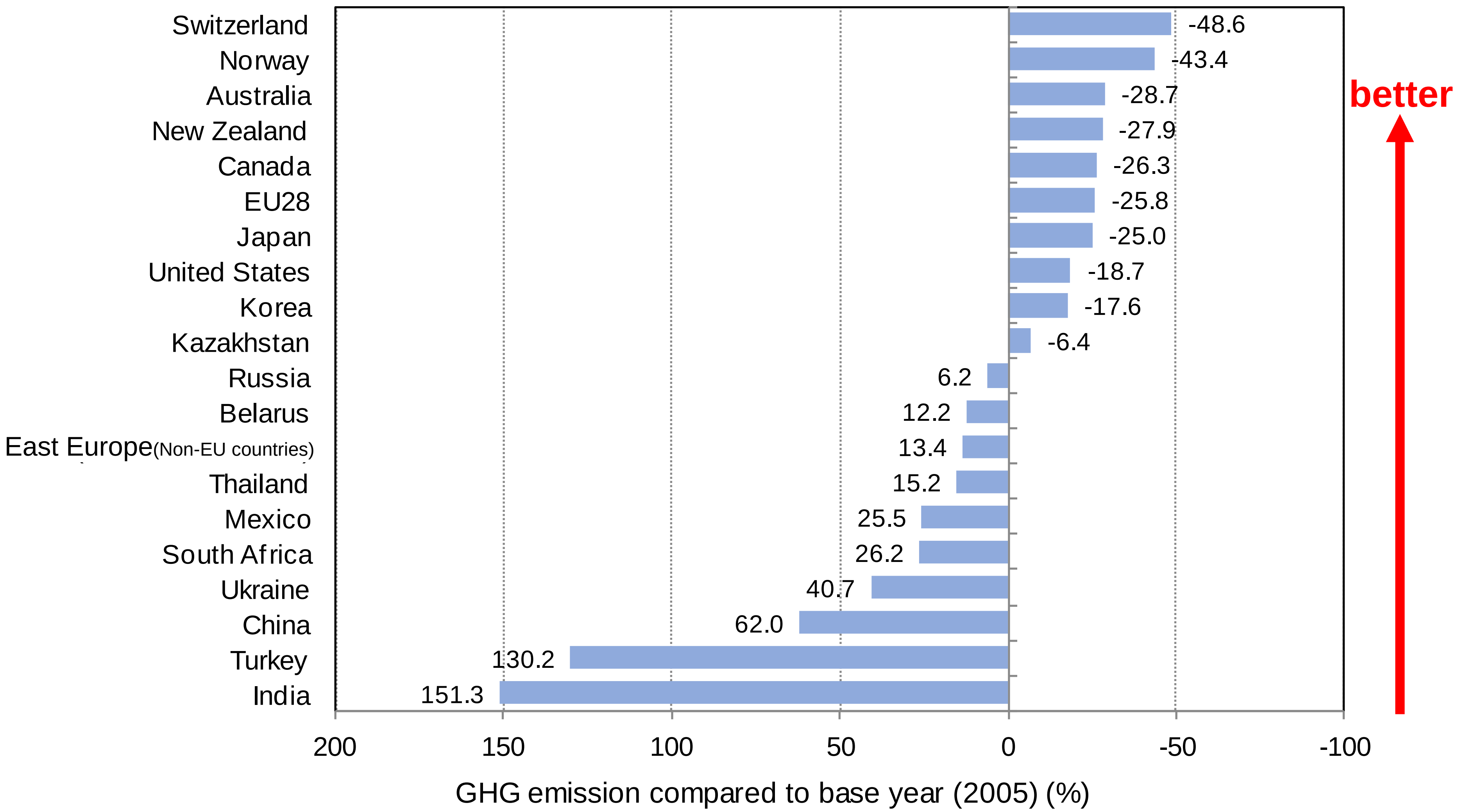
International comparison of emission reduction ratios from the base year of 2005



* 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 emission reduction ratios from the base year of 2012 (or 2010)



* 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.

GHG emissions per capita (1/3)

tCO2eq./capita

	1990	2005	2010	2020	2030
Japan	10.4	11.0	9.9	10.8	8.9
United States	24.4	24.2	22.0	17.6	14.8 to 15.2 (in 2025)
EU28	11.8	10.4	9.4	8.8	6.6
Switzerland	7.9	7.3	6.9	5.2	3.1
Norway	11.9	11.8	11.1	6.7	5.4
Australia	24.3	25.5	24.1	18.9	14.1 to 14.5
New Zealand	17.8	18.9	16.8	12.2	10.9
Canada	21.4	22.8	20.5	16.3	12.8
Russia	22.7	14.8	15.5	18.2 to 20.6	17.9 to19.1
China	3.3	6.0	7.8	10.2 to10.9	11.1 to12.4
Korea	6.9	12.0	13.4	11.1	10.9

GHG emissions per capita (2/3)

tCO2eq./capita

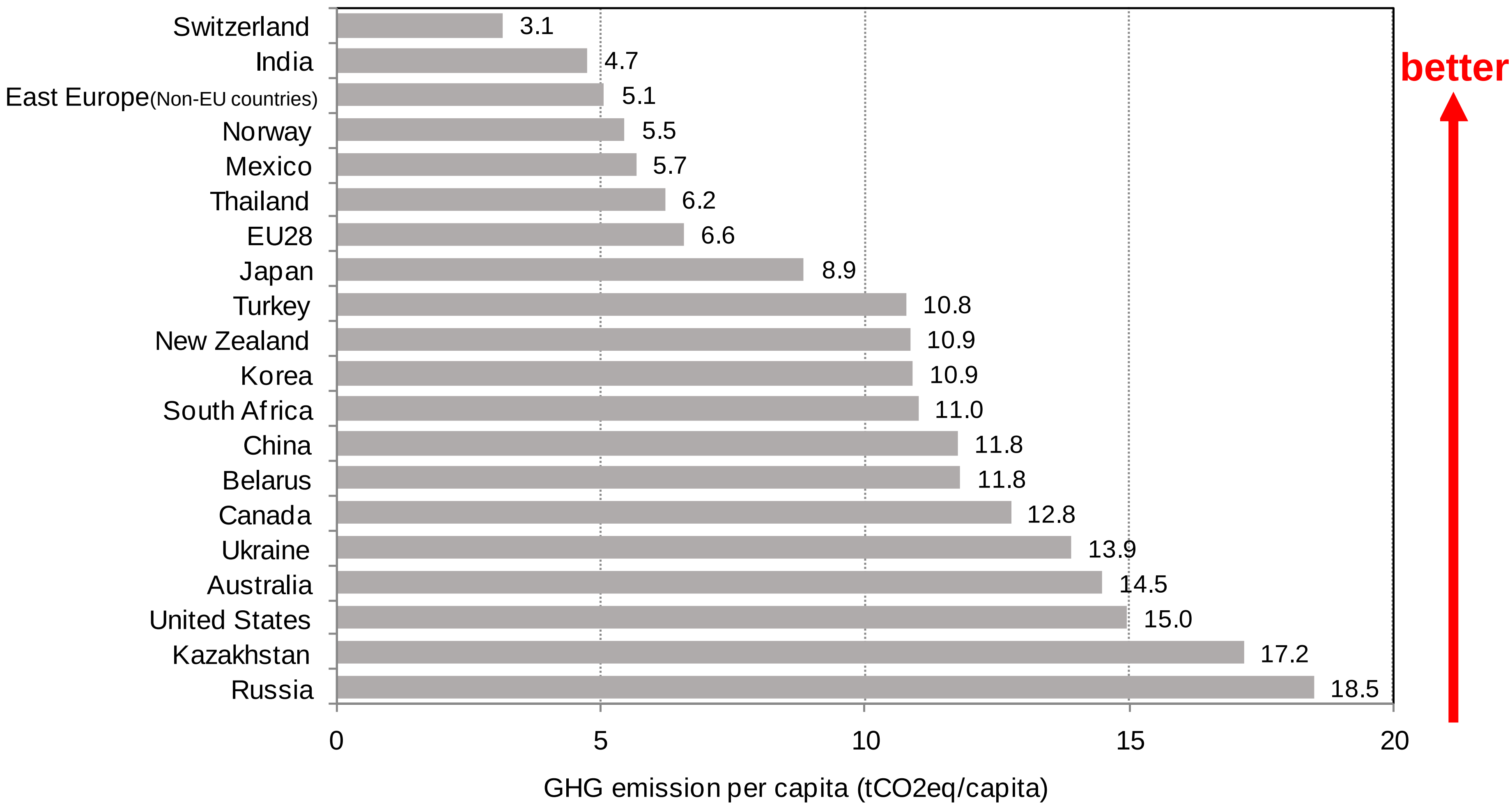
	1990	2005	2010	2020	2030
Mexico	4.9	5.2	5.1	4.3	5.7
Ukraine	18.3	9.1	8.4	17.4	13.9
Belarus	13.6	8.7	9.4	13.9 to 14.7	11.8
Kazakhstan	21.8	16.6	20.1	19.4	17.2
Albania	3.0	2.4	2.6		3.2
Macedonia	5.7	5.4	5.1		7.5
Moldova	8.5	3.3	3.4	8.3	4.2
Serbia	7.9	6.3	6.7		7.3
Thailand	3.4	5.2	5.8		6.2
India	1.5	1.8	2.3	3.7 to 3.9	4.7 to 4.9
Turkey	3.5	4.9	5.6		10.8
South Africa	9.5	9.2	9.5		11.0

GHG emissions per capita (3/3)

tCO2eq./capita

	1990	2005	2010	2020	2030
Singapore	11.0	10.9	11.2		11.3
Vietnam	1.3	2.5	3.3		6.9
Indonesia	6.2	12.6	7.9		7.3
Brazil	10.7	13.7	8.2	7.9 to 8.3	7.5 (in 2025)
Argentine	7.6	8.0	8.0		12.1
Morocco	1.5	2.0	2.2		3.9
Ethiopia	1.4	1.2	1.3		1.1
Kenya	1.5	1.3	1.3		1.6
Democratic Republic of the Congo	5.4	2.1	2.3		3.6
Dominican Republic	2.2	2.9	2.9		1.8

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.

GHG emissions per GDP (MER) (1/3)

kgCO2eq. per $2005

	1990	2005	2010	2020	2030
Japan	0.33	0.31	0.27	0.25	0.16
United States	0.76	0.55	0.50	0.34	0.27 to 0.28 (in 2025)
EU28	0.56	0.37	0.33	0.28	0.18
Switzerland	0.16	0.14	0.13	0.09	0.05
Norway	0.27	0.18	0.17	0.09	0.07
Australia	0.91	0.69	0.62	0.41	0.28 to 0.29
New Zealand	0.87	0.69	0.61	0.38	0.31
Canada	0.76	0.63	0.56	0.40	0.28
Russia	3.99	2.80	2.44	1.81 to 2.05	0.91 to 0.97
China	6.11	3.29	2.64	1.68 to1.80	1.07 to1.19
Korea	0.82	0.67	0.64	0.40	0.32

GHG emissions per GDP (MER) (2/3)

kgCO2eq. per $2005

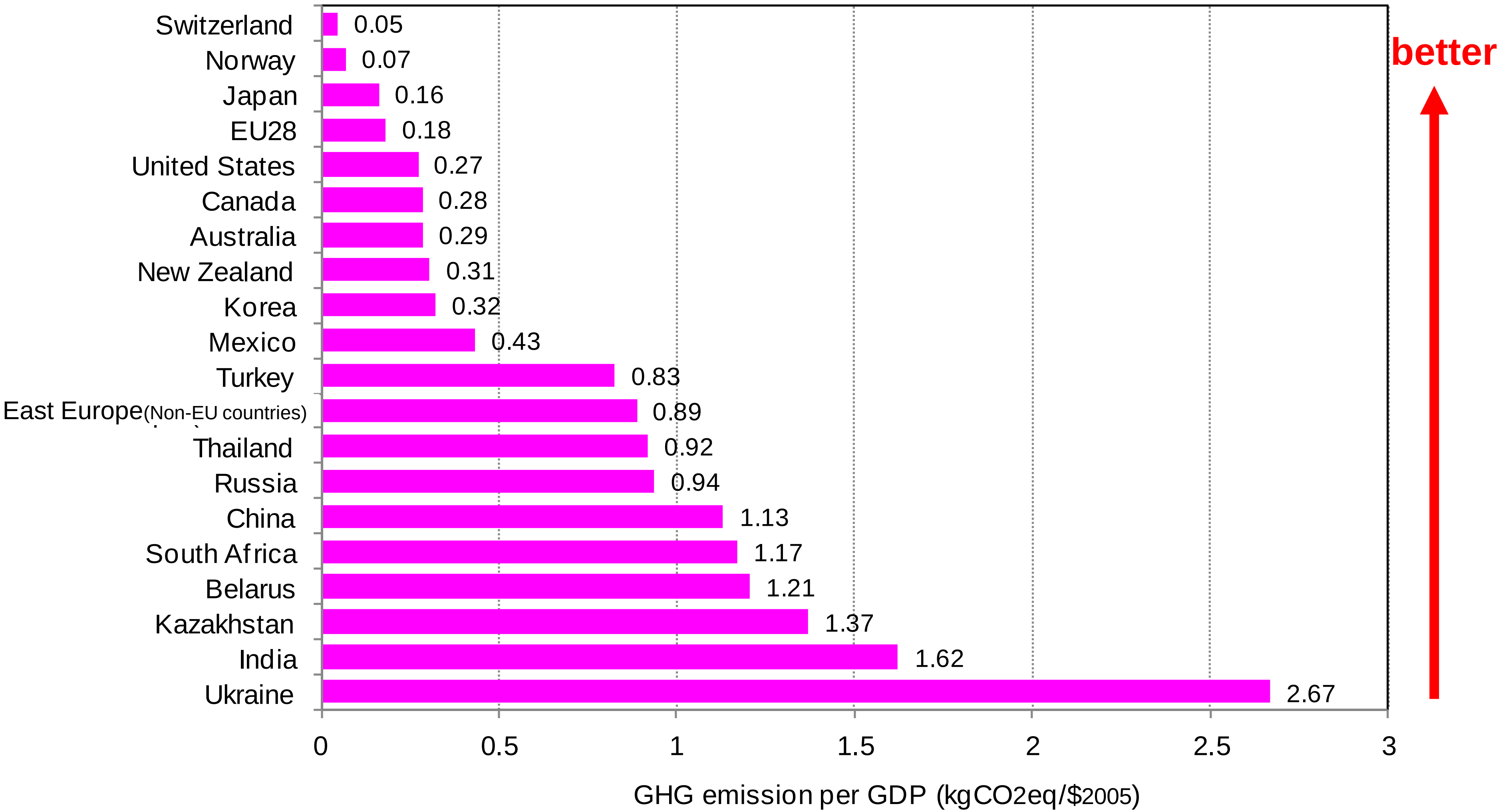
	1990	2005	2010	2020	2030
Mexico	0.76	0.66	0.64	0.42	0.43
Ukraine	6.89	4.97	4.28	6.07	2.67
Belarus	5.87	2.79	2.08	2.12 to 2.24	1.21
Kazakhstan	7.01	4.38	4.14	2.47	1.37
Albania	1.85	0.93	0.76		0.51
Macedonia	1.87	1.88	1.50		1.13
Moldova	6.25	4.16	3.52	5.69	1.74
Serbia	2.33	2.13	1.93		1.18
Thailand	2.19	1.93	1.84		0.92
India	3.71	2.50	2.23	2.12 to 2.24	1.62 to 1.67
Turkey	0.70	0.68	0.71		0.83
South Africa	2.04	1.80	1.68		1.17

GHG emissions per GDP (MER) (3/3)

kgCO2eq. per $2005

	1990	2005	2010	2020	2030
Singapore	0.67	0.39	0.33		0.24
Vietnam	4.63	3.69	3.80		3.57
Indonesia	7.34	9.90	5.05		2.20
Brazil	2.68	2.89	1.46	1.08 to 1.13	0.92 (in 2025)
Argentine	2.33	1.69	1.27		1.15
Morocco	0.99	1.02	0.91		0.89
Ethiopia	9.96	7.27	5.35		2.09
Kenya	2.76	2.40	2.20		1.41
Democratic Republic of the Congo	18.18	15.84	15.10		12.55
Dominican Republic	1.01	0.81	0.62		0.24

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.

Change in CO_2 intensity (GHG/GDP) (1/3)

	2012 to 2030 (or 2010 to 2030)
Japan	-3.3%/yr
United States (2012 to 2025)	-3.8 to -4.0%/yr
EU28	-2.9%/yr
Switzerland	-6.1%/yr
Norway	-4.6%/yr
Australia	-3.9 to 4.1%/yr
New Zealand	-3.7%/yr
Canada	-3.5%/yr
Russia	-4.8 to -5.1%/yr
China	-3.9 to -4.4%/yr
Korea	-3.4%/yr

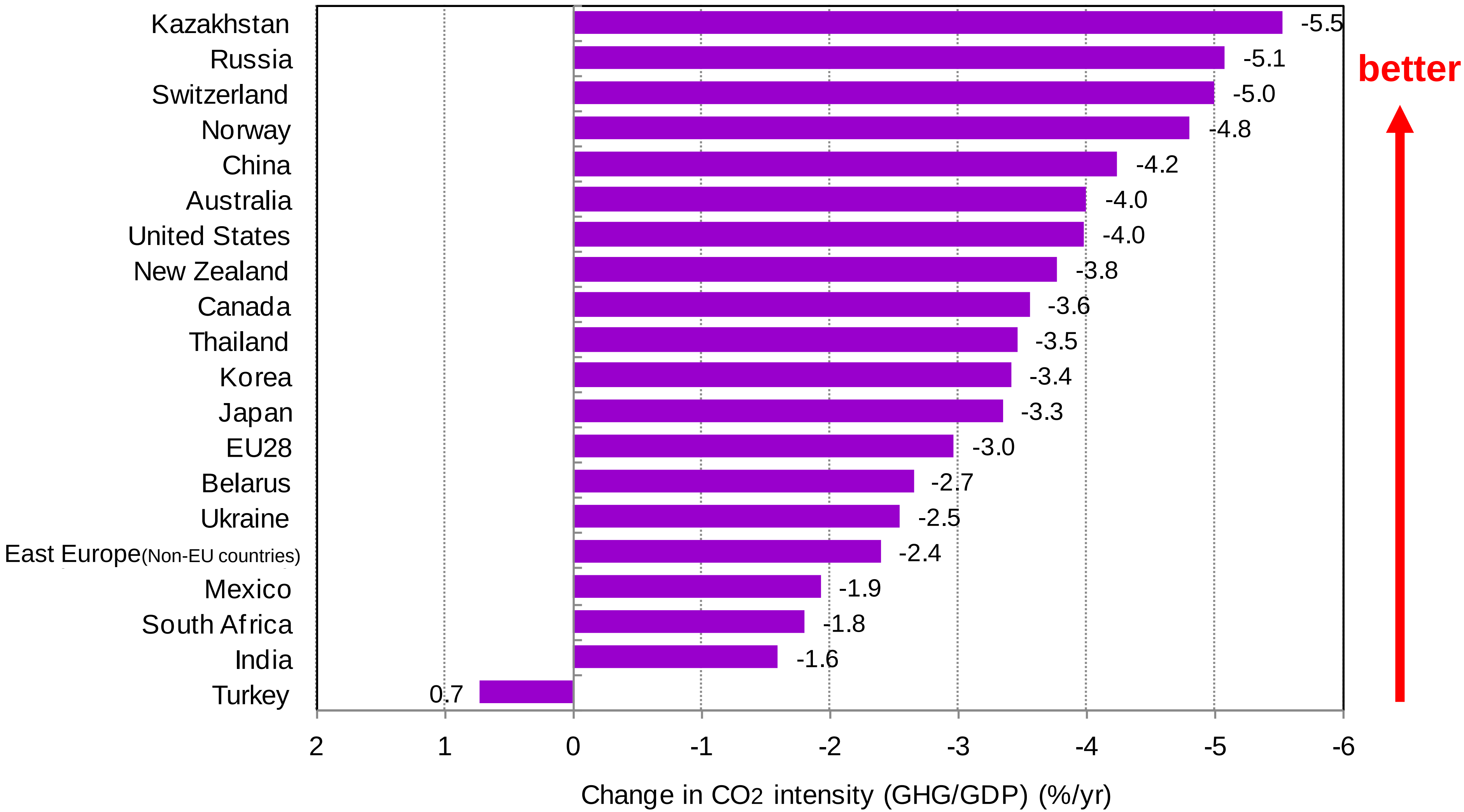
Change in CO_2 intensity (GHG/GDP) (2/3)

	2012 to 2030 (or 2010 to 2030)
Mexico	-1.9%/yr
Ukraine	-2.5%/yr
Belarus	-2.7%/yr
Kazakhstan	-5.5%/yr
Albania	-2.0%/yr
Macedonia	-1.4%/yr
Moldova	-3.5%/yr
Serbia	-2.5%/yr
Thailand	-3.5%/yr
India	-1.4%/yr to -1.6%/yr
Turkey	+0.7%/yr
South Africa	-1.8%/yr

Change in CO2 intensity (GHG/GDP) (3/3)

	2012 to 2030 (or 2010 to 2030)
Singapore	-1.7%/yr
Vietnam	-0.3%/yr
Indonesia	-4.2%/yr
Brazil (2010 to 2025)	-3.1%/yr
Argentine	-0.7%/yr
Morocco	-0.1%/yr
Ethiopia	-4.6%/yr
Kenya	-2.2%/yr
Democratic Republic of the Congo	-0.9%/yr
Dominican Republic	-4.7%/yr

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.

Emissions reduction ratio compared to BAU (1/2)

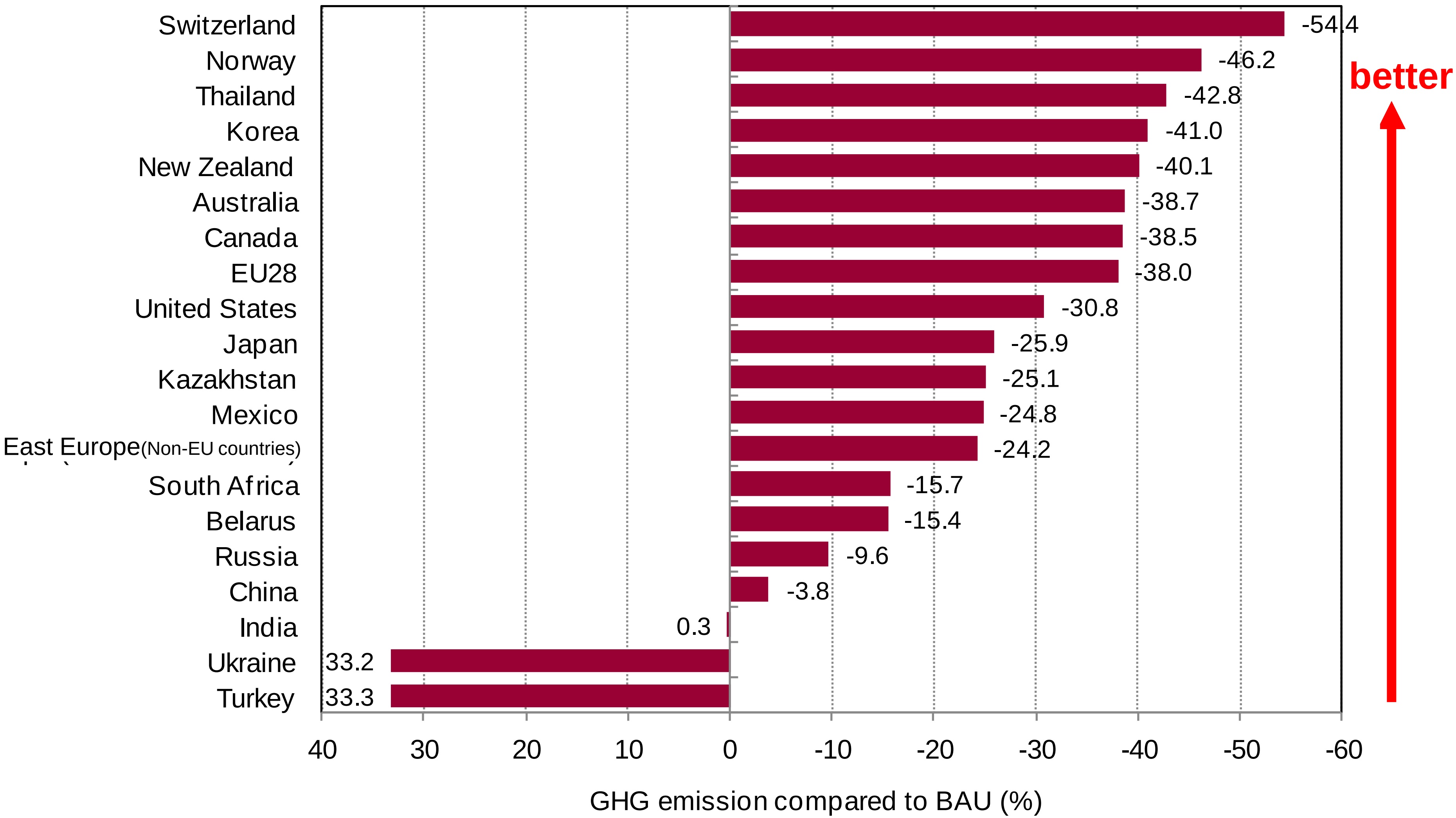
	Emissions reduction ratios compared to BAU	
	Adoption of the BAU described in the INDCs	Adoption of the BAU estimated by RITE Model
Japan: -26% relative to 2013 (by 2030)	—	-26%
United States: -26 to 28% relative to 2005 (by 2025)	—	-30 to -32%
EU28: -40% relative to 1990 (by 2030)	—	-38%
Switzerland: -50% relative to 1990 (by 2030)	—	-54%
Norway: -40% relative to 1990 (by 2030)	—	-46%
Australia: -26 to -28% relative to 2005 (by 2030)	—	-39 to -40%
New Zealand: -30% relative to 2005 (by 2030)	—	-40%
Canada: -30% relative to 2005 (by 2030)	—	-39%
Russia: -25 to 30% relative to 1990 (by 2030)	—	-7 to -13%
China: -60 to -65% relative to CO_2 emission intensity (by 2030)	—	+1 to -9%
Korea: -37% relative to BAU (by 2030)	-37%	-41%

Emissions reduction ratio compared to BAU (2/2)

	Emissions reduction ratios compared to BAU	
	Adoption of the BAU described in the INDCs	Adoption of the BAU estimated by RITE Model
Mexico*: -25% relative to BAU (by 2030)	-22%	-25%
Ukraine: -40% relative to 1990 (by 2030)	—	+32%
Belarus: -28% relative to 1990 (by 2030)	—	-15%
Kazakhstan: -15% relative to 1990 (by 2030)	—	-25%
East Europe (Non-EU countries)	—	-24%
Thailand:-20% relative to BAU (by 2030)	-20%	-43%
India: -33 to -35% relative to GHG emission intensity in 2005 (by 2030)	—	+3 to +0%
Turkey: -21% relative to BAU (by 2030)	-21%	+33%
South Africa: 614MtCO_2eq/yr (by 2030)	—	-16%

* Mexico's reduction target in INDC (-25%) includes both GHG and black carbon (BC) emissions. The rates in the table are based on the GHG target.

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.

CO_2 marginal abatement costs for the INDCs of major countries (estimated by RITE DNE21+) (1/2)

	Marginal abatement cost ($/t$CO_2$eq)	
	Low case	High case
Japan：-26% by 2030 compared to 2013	**About 380*** (for the target of energy-related CO_2 only, the estimate is about 260)	
United States：-26% to -28% by 2025 compared to 2005	**76**	**94**
EU28：-40% by 2030 compared to 1990	**210**	
Switzerland：-50% by 2030 compared to 1990	**380**	
Norway：-40% by 2030 compared to 1990	**70**	
Australia：-26% to -28% by 2030 compared to 2005	**33**	
New Zealand：-30% by 2030 compared to 2005	**95**	
Canada：-30% by 2030 compared to 2005	**166**	
Russia：-25% to -30% by 2030 compared to 1990	**1**	**7**
China：-60 to -65% of CO_2 intensity by 2030 compared to 2005	**up to 0**	**up to 0**
Korea：-37% by 2030 compared to BAU	**144**	

* Emission reduction target (-26%) is assumed to be achieved by mitigation measures excluding LULUCF (Emission reduction by absorption (-2.6%) is not considered). This treatment is applied for the all evaluated countries.

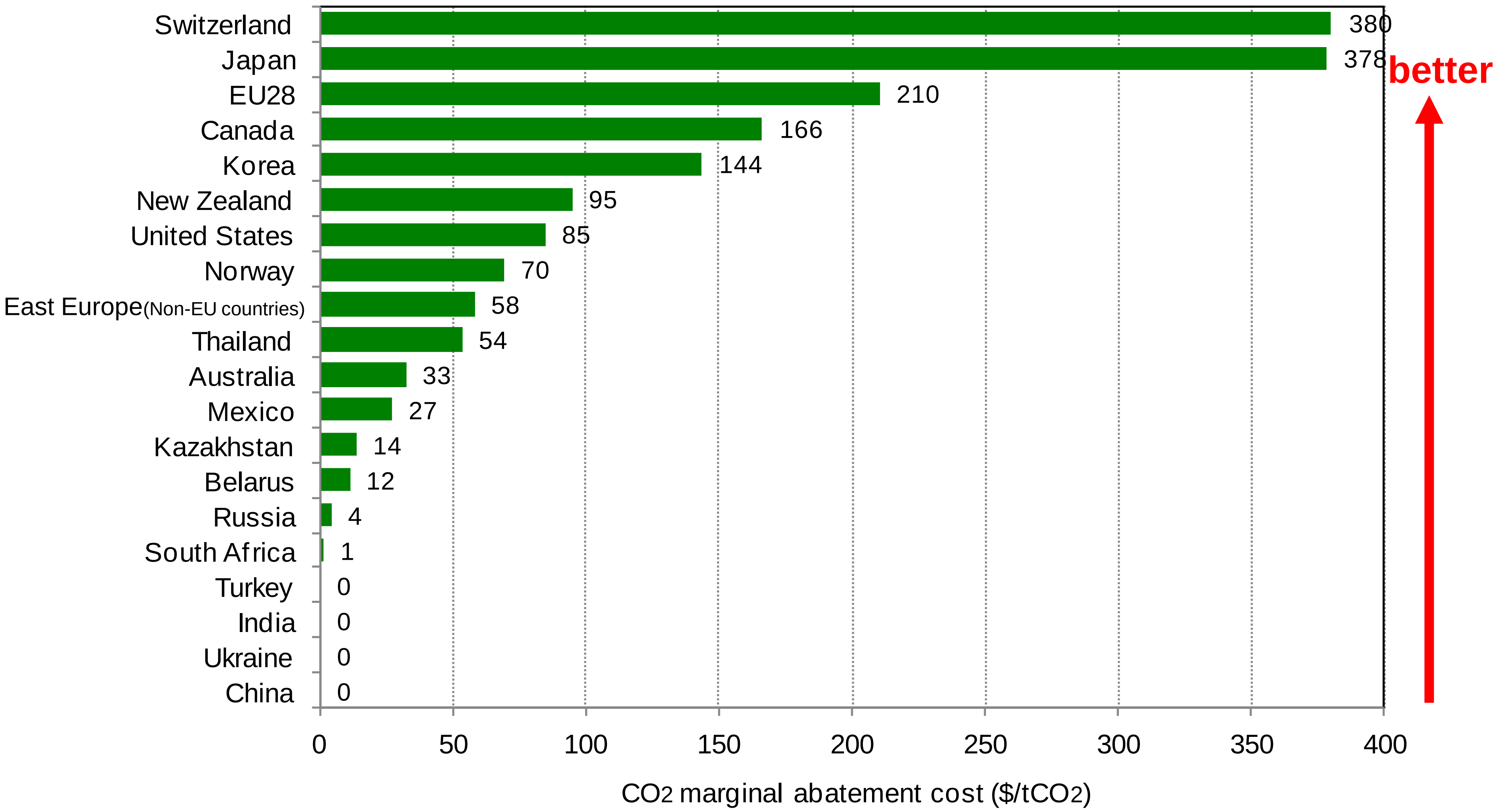
Note: The estimated marginal abatement costs of US, EU28, and Russia are higher than the previous evaluation, because INDCs of other countries are additionally considered in this version, and then low CO_2 intensity energy import of the three regions is reduced relative to that in the previous version.
(http://www.rite.or.jp/Japanese/labo/sysken/about-global-warming/download-data/E-Energymix_INDCs_20150818.pdf)

CO_2 marginal abatement costs for the INDCs of major countries (estimated by RITE DNE21+) (2/2)

	CO_2 marginal abatement cost (\$/tCO_2eq)	
	Low case	High case
Mexico*：-25% by 2030 compared to BAU	**27**	
Ukraine：-40% by 2030 compared to 1990	**～0**	
Belarus：-28% by 2030 compared to 1990	**12**	
Kazakhstan：-15% by 2030 compared to 1990	**14**	
East Europe (Non-EU member)	**58**	
Thailand：-20% by 2030 compared to BAU	**54**	
India：-33% to -35% of GHG intensity by 2030 compared to 2005	**up to 0**	**up to 0**
Turkey：-21% by 2030 compared to BAU	**up to 0**	
South Africa：614MtCO_2eq/yr by 2030	**1**	

* Emission reduction target of Mexico includes black carbon. Emission reduction of black carbon is not considered in our evaluation (-22% compared to BAU).

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.

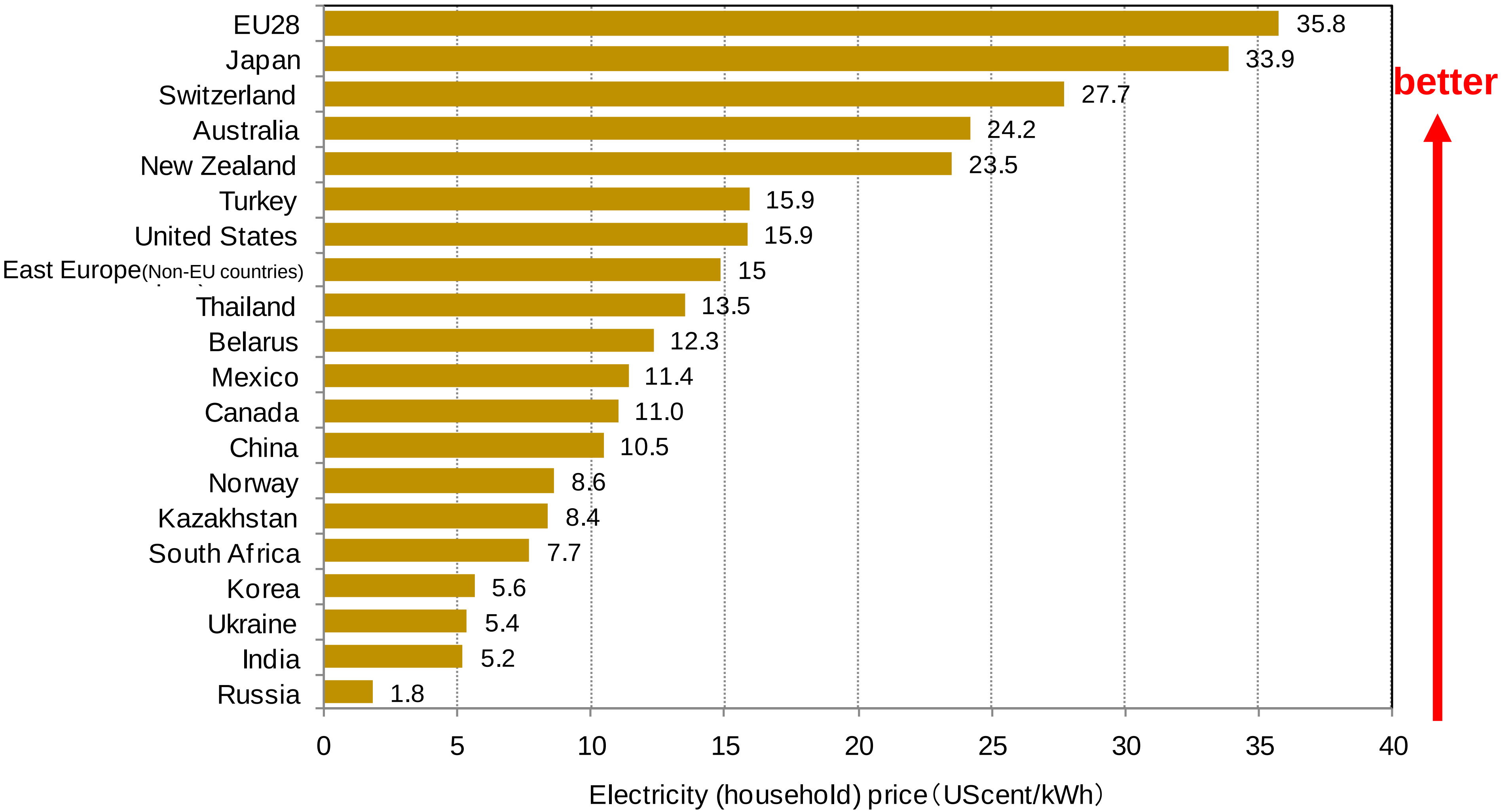
Estimated retail prices of energy of INDCs (estimated by RITE DNE21+) (1/2)

	Retail prices of energy in 2030			
	Electricity (household) (US cent/kWh)	City Gas (household) (US$/GJ)	Gasoline (95 RON) (US$/L)	Diesel (US$/L)
Japan	33.9	60.7	2.18	2.07
United States (2012 to 2025)	15.4 to 16.3	12.6 to 13.7	0.80 to 0.86	0.92 to 0.98
EU28	35.8	32.3	2.30	2.12
Switzerland	27.7	51.8	2.58	2.68
Norway	8.6	n.a	2.00	1.84
Australia	24.2	n.a	1.12	1.15
New Zealand	23.5	35.0	1.67	1.63
Canada	11.0	17.1	1.52	1.42
Russia	1.3 to 2.3	1.6 to 2.0	0.64 to 0.65	0.27
China	9.9 to 11.1	n.a	1.09 to1.10	1.02 to 1.03
Korea	5.6	23.5	1.48	0.95

Estimated retail prices of energy of INDCs (estimated by RITE DNE21+) (2/2)

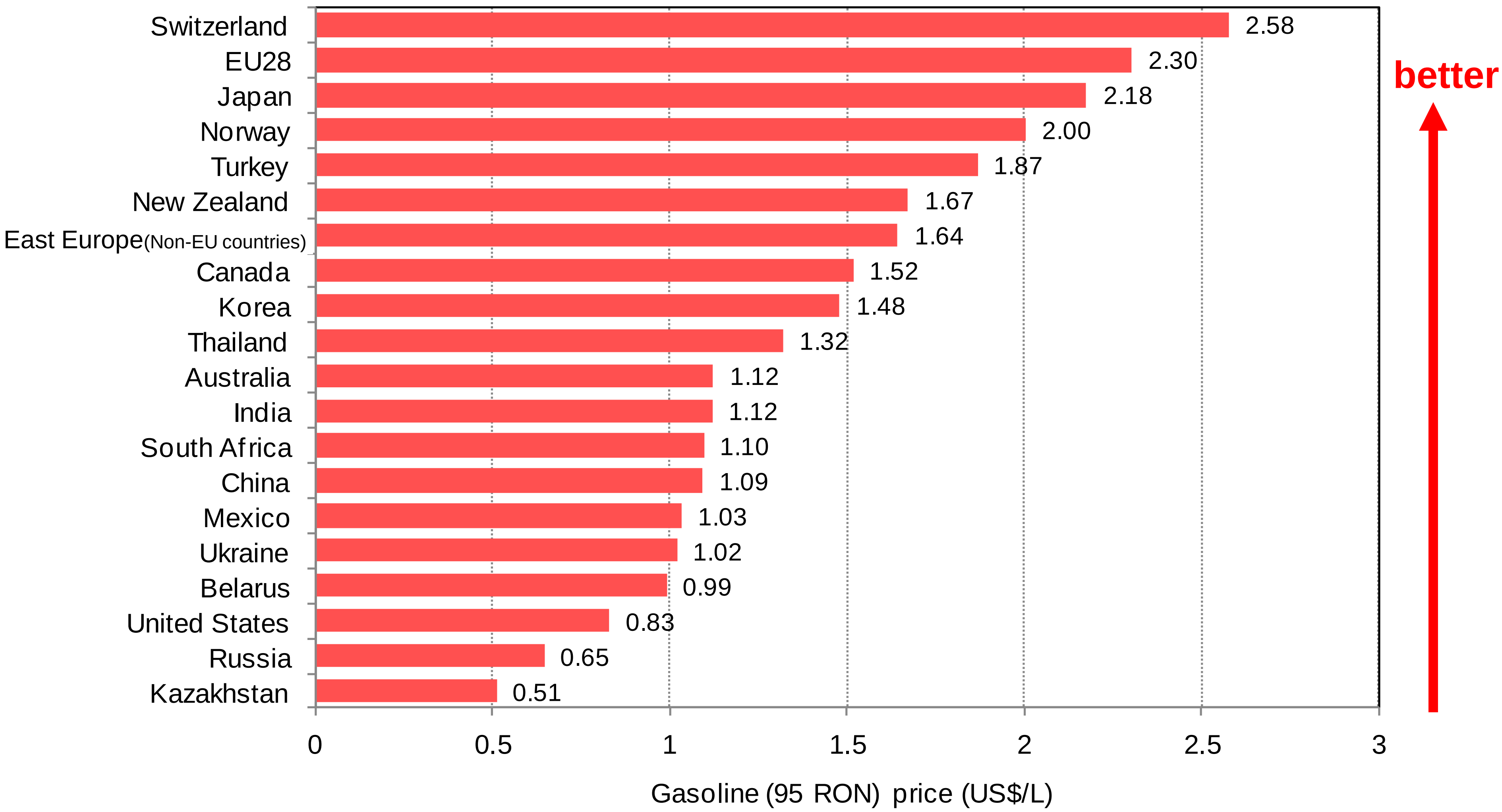
	Retail prices of energy in 2030			
	Electricity (household) (US cent/kWh)	City gas (household) (US$/GJ)	Gasoline (95 RON) (US$/L)	Diesel (US$/L)
Mexico	11.4	11.0	1.03	1.04
Ukraine	5.4	n.a	1.02	0.99
Belarus	12.3	n.a	0.99	0.84
Kazakhstan	8.4	n.a	0.51	0.40
East Europe (Non-EU countries)	14.9	n.a	1.64	1.70
Thailand	13.5	n.a	1.32	1.02
India	5.2	n.a	1.12	0.90
Turkey	15.9	10.8	1.87	1.65
South Africa	7.7	n.a	1.10	0.96

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 retail prices of energy (gasoline)



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

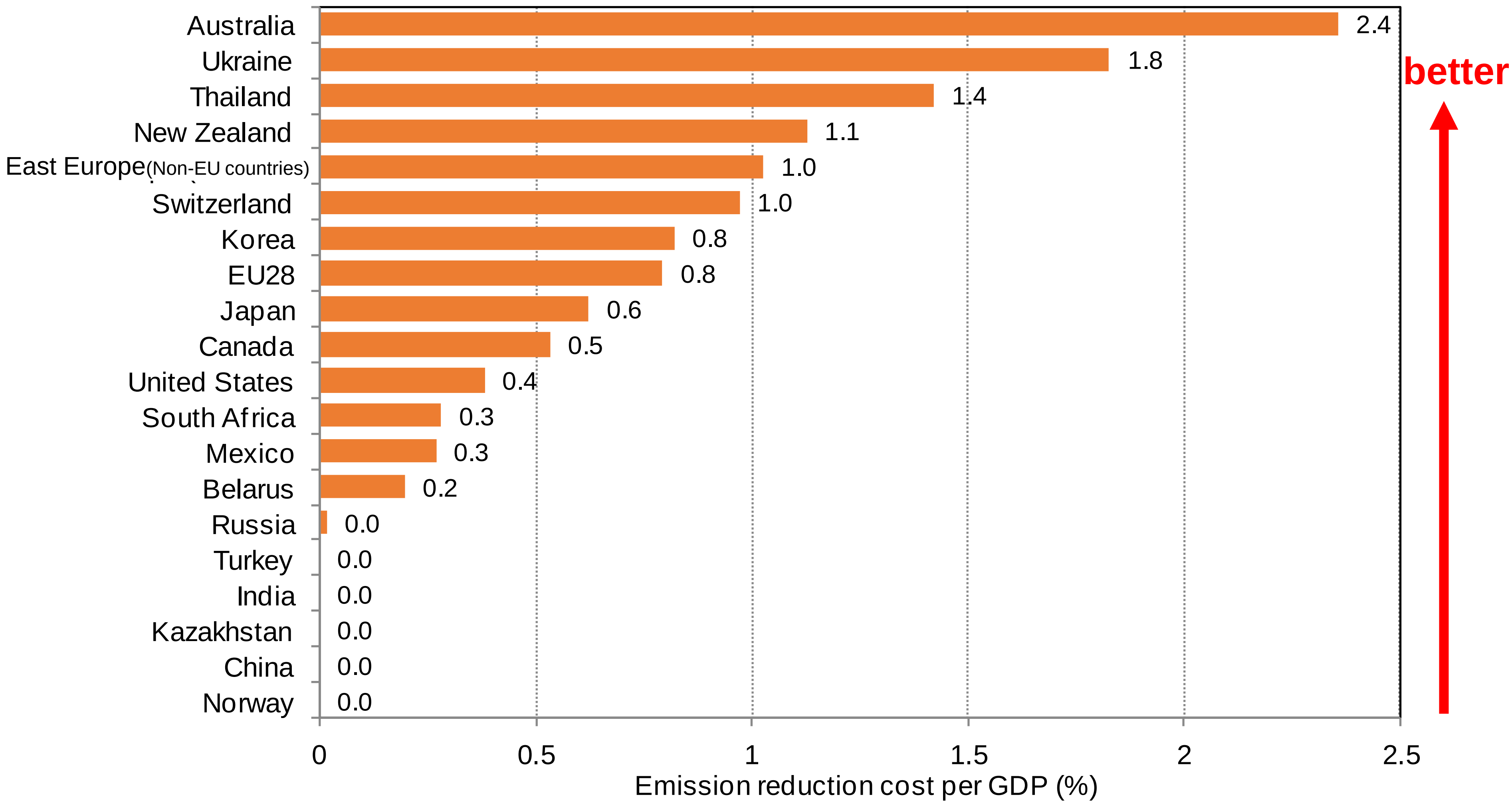
Estimated emissions reductions costs per GDP of INDCs (estimated by RITE DNE21+) (1/2)

	Emissions reductions cost per GDP (%)	
	Low	High
Japan: -26% relative to 2013 (by 2030)	**around 0.6**	
United States: -26 to 28% relative to 2005 (by 2025)	**0.35**	**0.41**
EU28: -40% relative to 1990 (by 2030)	**0.79**	
Switzerland: -50% relative to 1990 (by 2030)	**0.97**	
Norway: -40% relative to 1990 (by 2030)	**up to 0**	
Australia: -26 to -28% relative to 2005 (by 2030)	**2.36**	
New Zealand: -30% relative to 2005 (by 2030)	**1.13**	
Canada: -30% relative to 2005 (by 2030)	**0.53**	
Russia: -25 to 30% relative to 1990 (by 2030)	**up to 0**	**up to 0**
China: -60 to -65% relative to CO2 emission intensity (by 2030)	**up to 0**	**up to 0**
Korea: -37% relative to BAU (by 2030)	**0.82**	

Estimated emissions reductions costs per GDP of INDCs (estimated by RITE DNE21+) (2/2)

	Emissions reductions cost per GDP (%)	
	Low	High
Mexico*: -25% relative to BAU (by 2030)	0.27	
Ukraine: -40% relative to 1990 (by 2030)	1.83	
Belarus: -28% relative to 1990 (by 2030)	0.20	
Kazakhstan: -15% relative to 1990 (by 2030)	up to 0	
East Europe (Non-EU countries)	1.03	
Thailand:-20% relative to BAU (by 2030)	1.42	
India: -33 to -35% relative to GHG emission intensity in 2005 (by 2030)	up to 0	
Turkey: -21% relative to BAU (by 2030)	up to 0	
South Africa: 614MtCO_2eq/yr (by 2030)	0.28	

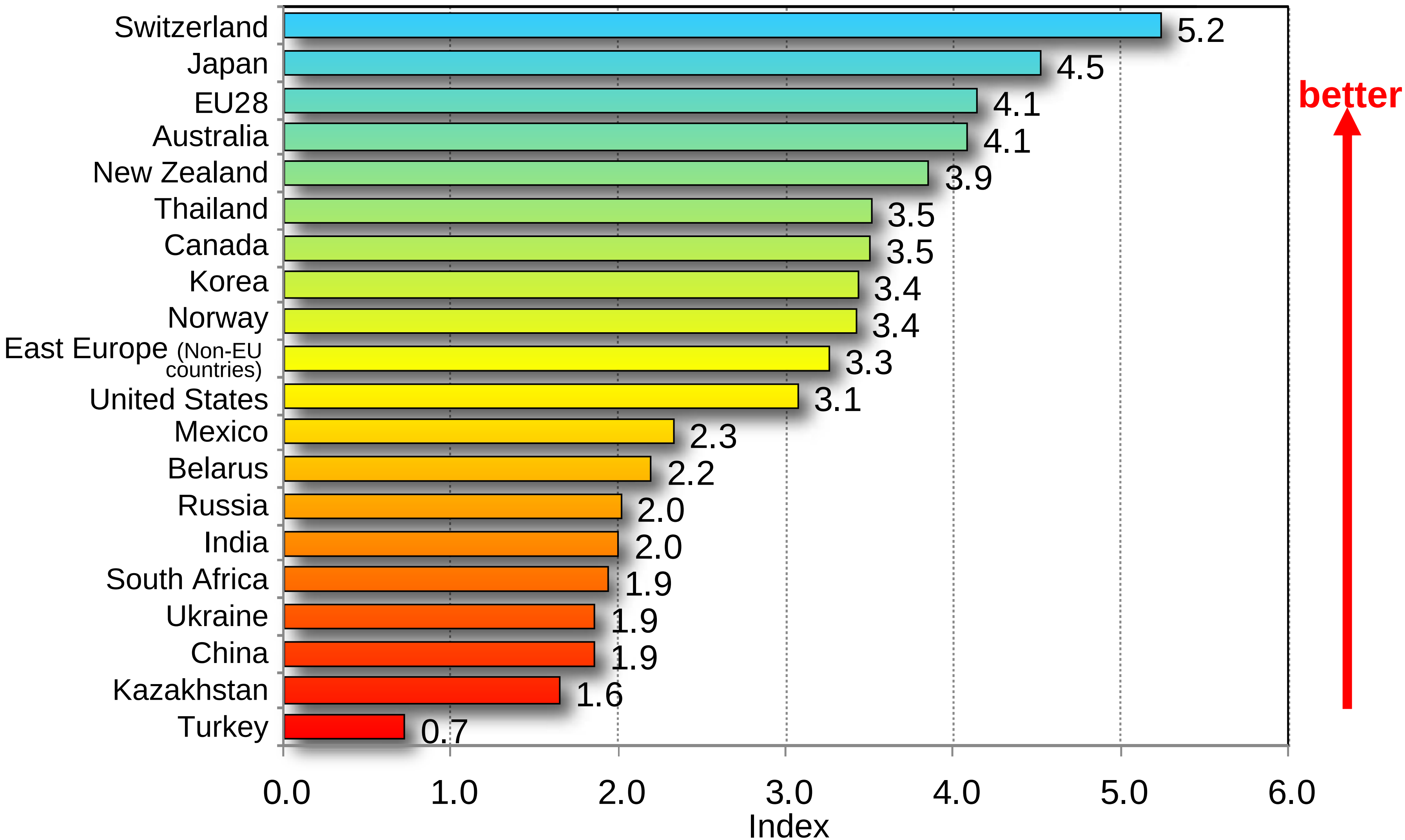
International comparison of emission reduction costs per GDP



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

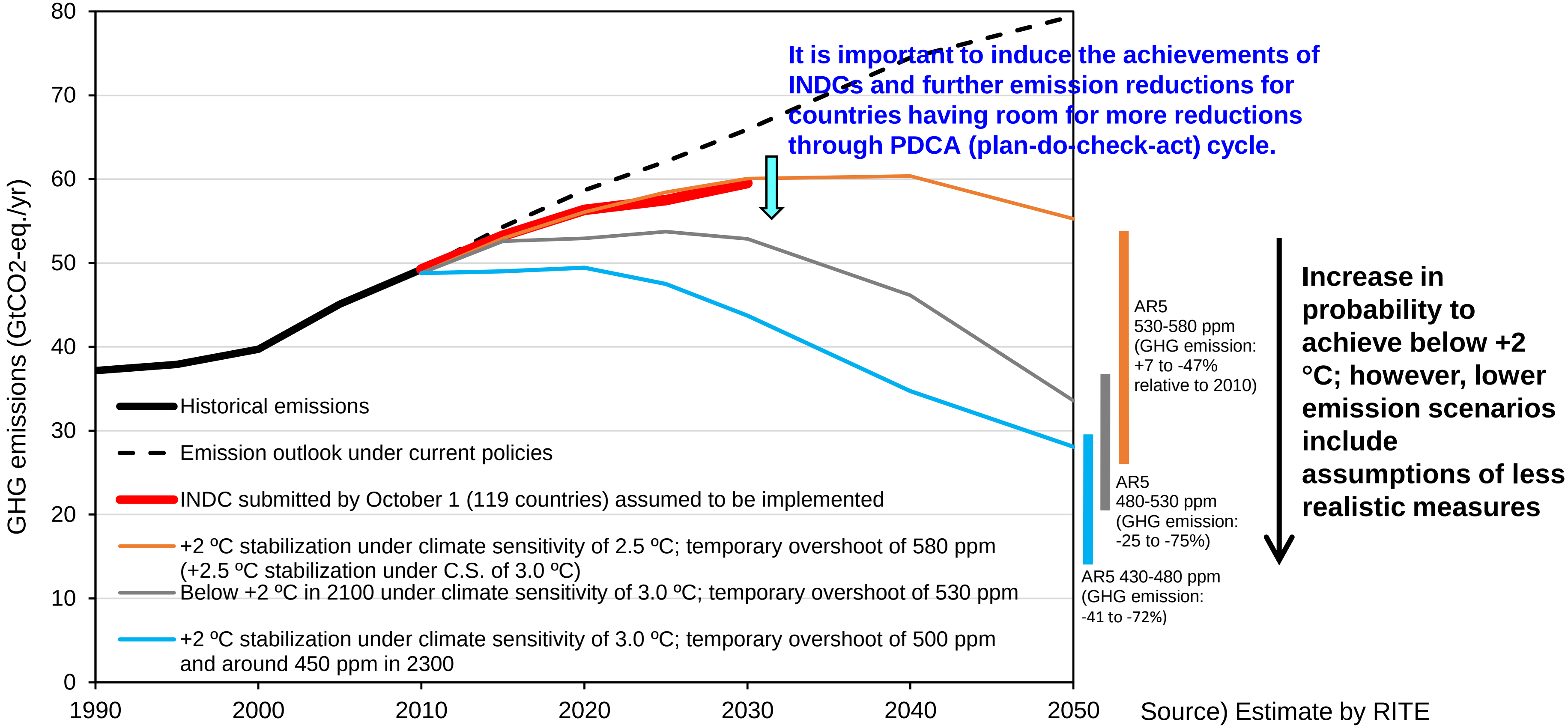
Integrated ranking of emission reduction efforts (ambition) of INDCs

The ranking result integrated from the results of six categorized indicators by using the assumed weighting values (see p.16)



Expected Global GHG Emissions of the Aggregated INDCs

Expected global GHG emissions of the aggregated INDCs and the corresponding emission pathways up to 2050 toward +2 °C goal



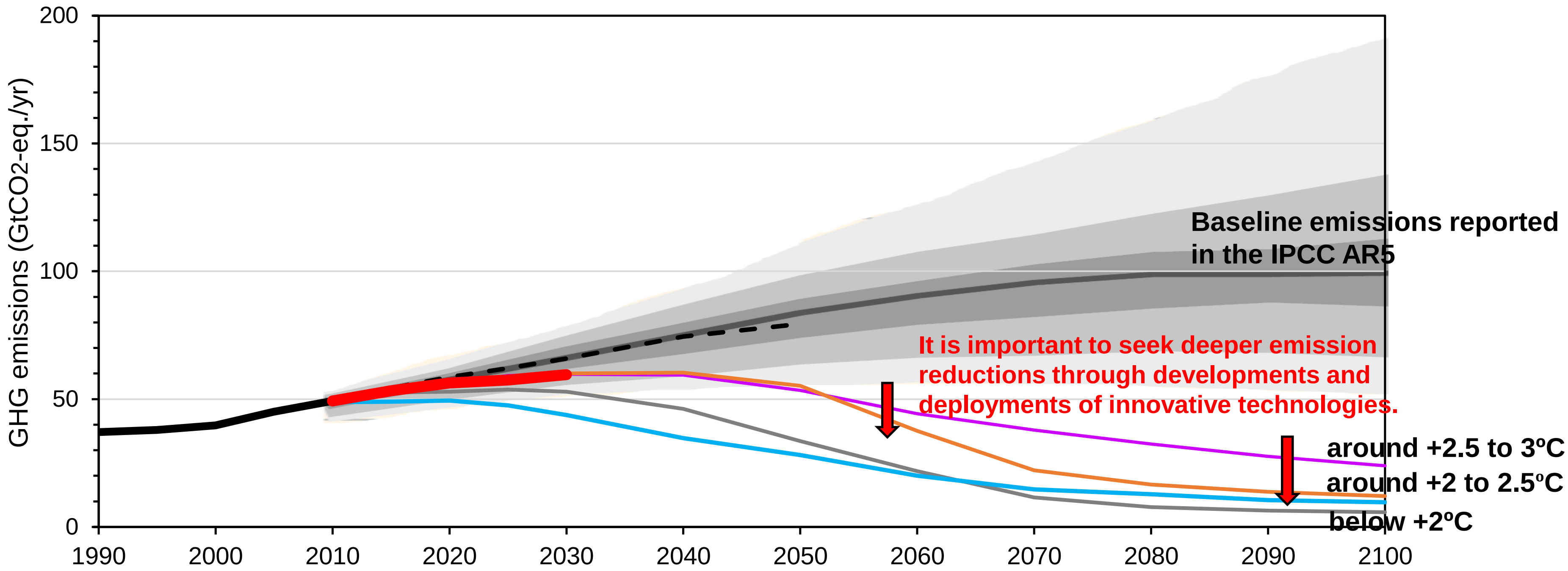
Source) Estimate by RITE

Note) Climate sensitivity is still largely uncertain. According to the IPCC AR5, the equilibrium climate sensitivity (ECS) of 1.5 to 4.5 °C is likely. The emission pathways that are consistent with +2 °C under ECS of 3.0 °C and 2.5 °C are shown. See also Y. Kaya et al., The uncertainty of climate sensitivity and its implication for the Paris negotiation, Sustainability Science.

- 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). Some of the emission reduction effects are estimated to be offset due to carbon leakages caused by large differences in marginal emission reduction costs.

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

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

Summary

Summary:
Evaluation of emission reduction efforts

- We evaluated 'emission reduction efforts (degree of ambition)' of INDCs from various aspects, using multiple measurable indexes, for the nations who had submitted them before October 1st, 2015.
- Swiss INDC was evaluated as the most ambitious one, being regarded to require the largest effort for its realization among those evaluated quantitatively here. The second was Japan, and the third was the EU28.
- INDCs of Turkey, Kazakhstan, China etc. were evaluated to be relatively inadequate in terms of emission reduction effort.
- 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, 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. There are several nations (Iran, Saudi-Arabia, Pakistan, Egypt, Venezuela as relatively larger emitters) who do not submit their INDCs, which should be recognized more problematic than those whose INDCs were evaluated inadequate in our study.

Summary: Perspective of global GHG emissions

- Global emissions will be 60 GtCO2eq in 2030 if all the nations realize their submitted INDCs. (Current emissions are 52–53GtCO2eq) 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. (Correspondingly, 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.
- PDCA cycle including international review system should be designed and operated so that submitted INDCs may be realized for all the nations and further emissions reduction may be endeavored for the nations who have room for it.

Appendix

Population prospects (millions)

	2010	2020	2030
Japan	127	124	118
United States	312	340	364
EU28	507	515	515
Switzerland	8	8	8
Norway	5	6	6
Australia	22	25	27
New Zealand	4	5	5
Canada	34	37	40
Russia	144	139	132
China	1367	1445	1477
Korea	48	49	49
Mexico	118	128	135
Ukraine	46	44	41
Belarus	9	9	8
Kazakhstan	16	17	17
East Europe (Non-EU countries)	23	23	22
Thailand	66	70	72
India	1206	1357	1474
Turkey	72	80	86
South Africa	51	54	56
The World Total	***6916***	***7679***	***8308***

Source) RITE estimates based on the 2008 UN population prospects in the medium variants. For statistical values up to 2010, The UN World Population Prospects 2012 are used.

GDP Prospects (MER, %/yr)

	2010—2020	2020−2030
Japan	1.4	1.9
United States	2.6	2.0
EU28	1.2	1.3
Switzerland	1.4	1.2
Norway	1.8	1.6
Australia	2.7	1.8
New Zealand	2.4	1.6
Canada	2.1	1.7
Russia	4.3	6.3
China	7.7	5.6
Korea	3.0	1.9
Mexico	3.2	3.0
Ukraine	3.2	5.3
Belarus	3.2	3.4
Kazakhstan	5.4	5.0
East Europe (Non-EU countries)	2.2	3.8
Thailand	4.3	4.0
India	6.5	5.9
Turkey	4.0	2.8
South Africa	2.5	3.4
The World Average	***3.0***	***2.9***

Source) RITE estimates. Our estimates are not so different form USDOE/EIA International Energy Outlook and IEA World Energy Outlook. (In consideration of the differences between PPP and MER)

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

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 CO_2
- 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)