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Industrial Decarbonization, Border Measures and Climate Clubs

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The Emissions Reduction Efforts and Effects, and the Impacts on Competitiveness and Border Carbon Adjustment

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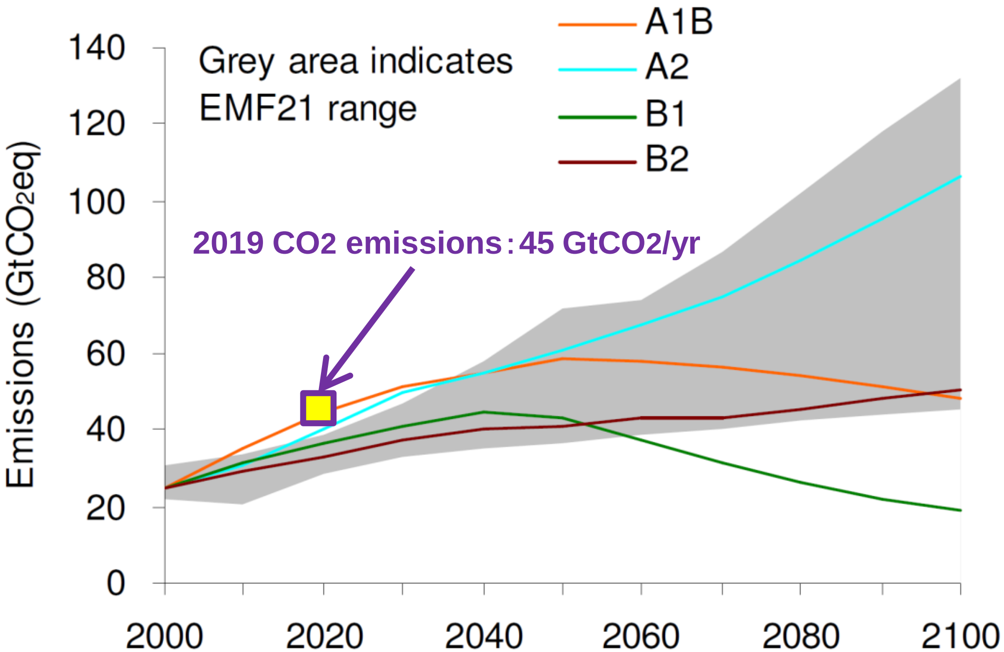
Key issues

- **How to measure the comparable emission reduction efforts, and how mechanisms will achieve the global emissions reductions effectively.**
- **Estimations of CO_2 marginal abatement costs for the emissions reduction targets of NDCs, and the expected economic impacts (Model estimations)**
- **The expected effects of BCA for avoiding carbon leakage (Model estimation)**
- **How to measure carbon prices for the BCA: explicit carbon prices vs implicit carbon prices**
  - Explicit carbon prices: is relatively easy to estimate.
  - Implicit carbon prices: is not easy to estimate, but the global emissions reduction effects are determined by the embodied CO_2 intensity of products which are induced by the implicit prices including baseline final energy prices.
- **How to measure sectoral energy or CO2 intensity, which has impacts on emissions more directly rather than carbon prices**

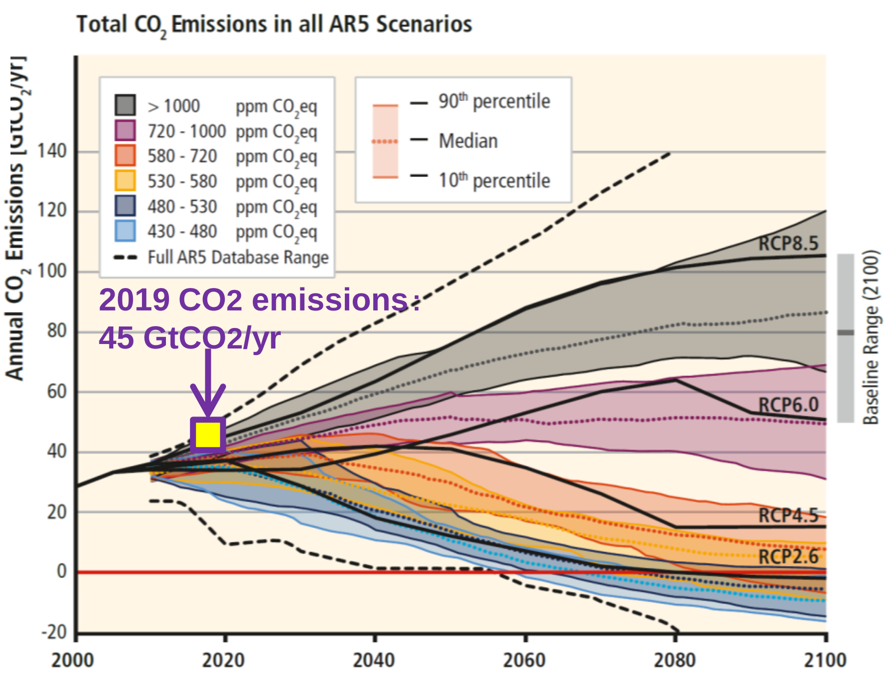
The estimated baseline emissions in the IPCC AR5 (2007) and AR6 (2014) v.s. the actual emissions in 2019

AR5 (2007): baseline CO2 emissions



- ✓ The actual emission in 2019 was nearly the upper range of all of the baseline emissions estimated by IAMs in the IPCC AR5 and AR6, while large efforts for emissions reduction have been conducted.
- ✓ It can be afraid that CO2 intensive industries had moved from developed countries to developing countries more than those that IAMs had estimated.

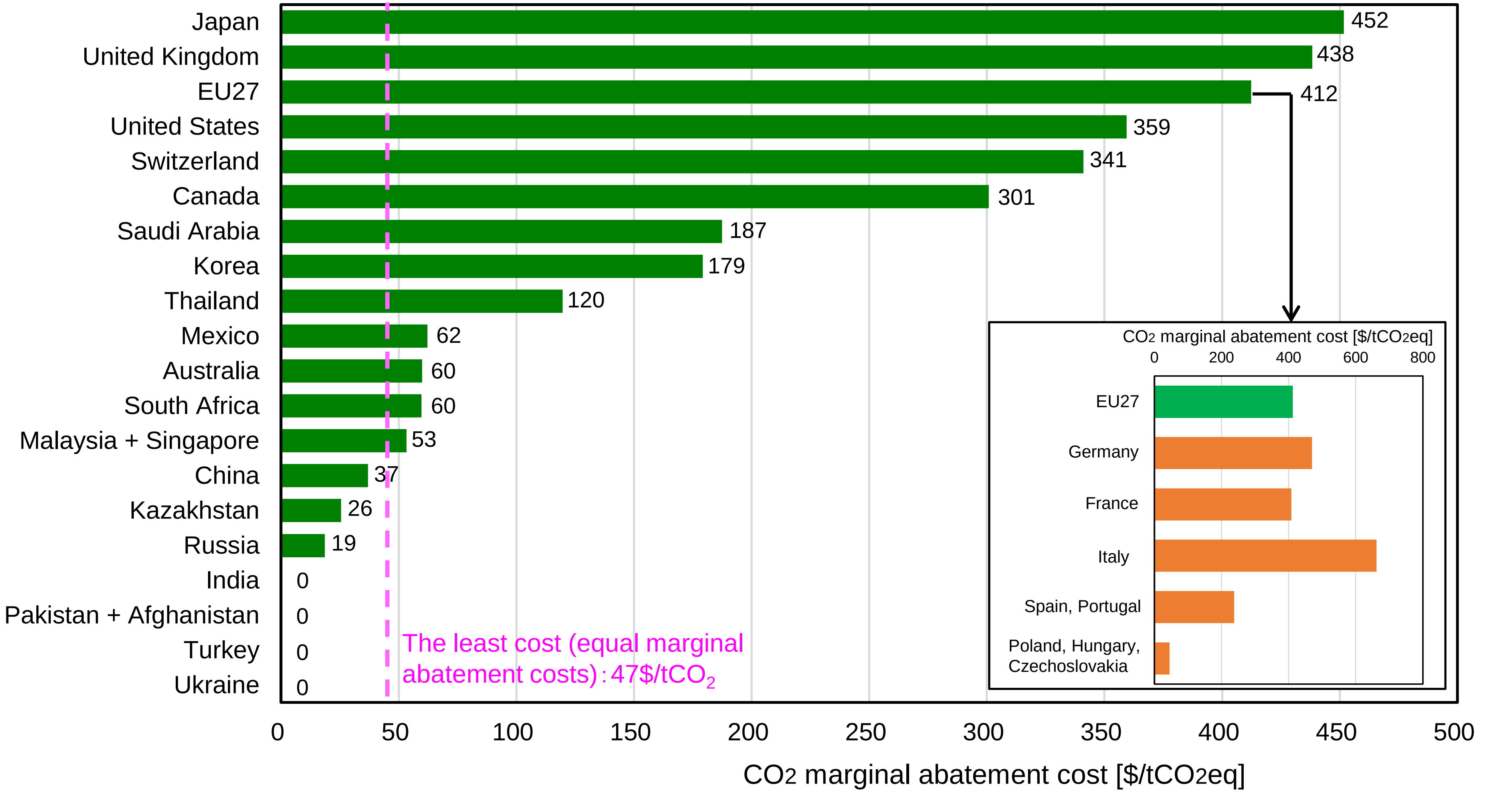
AR6 (2014): all pathways including baseline emissions



Comparisons in CO_2 marginal abatement costs for achieving NDCs in 2030 across countries

Estimations by using a bottom-up energy systems model, DNE21+

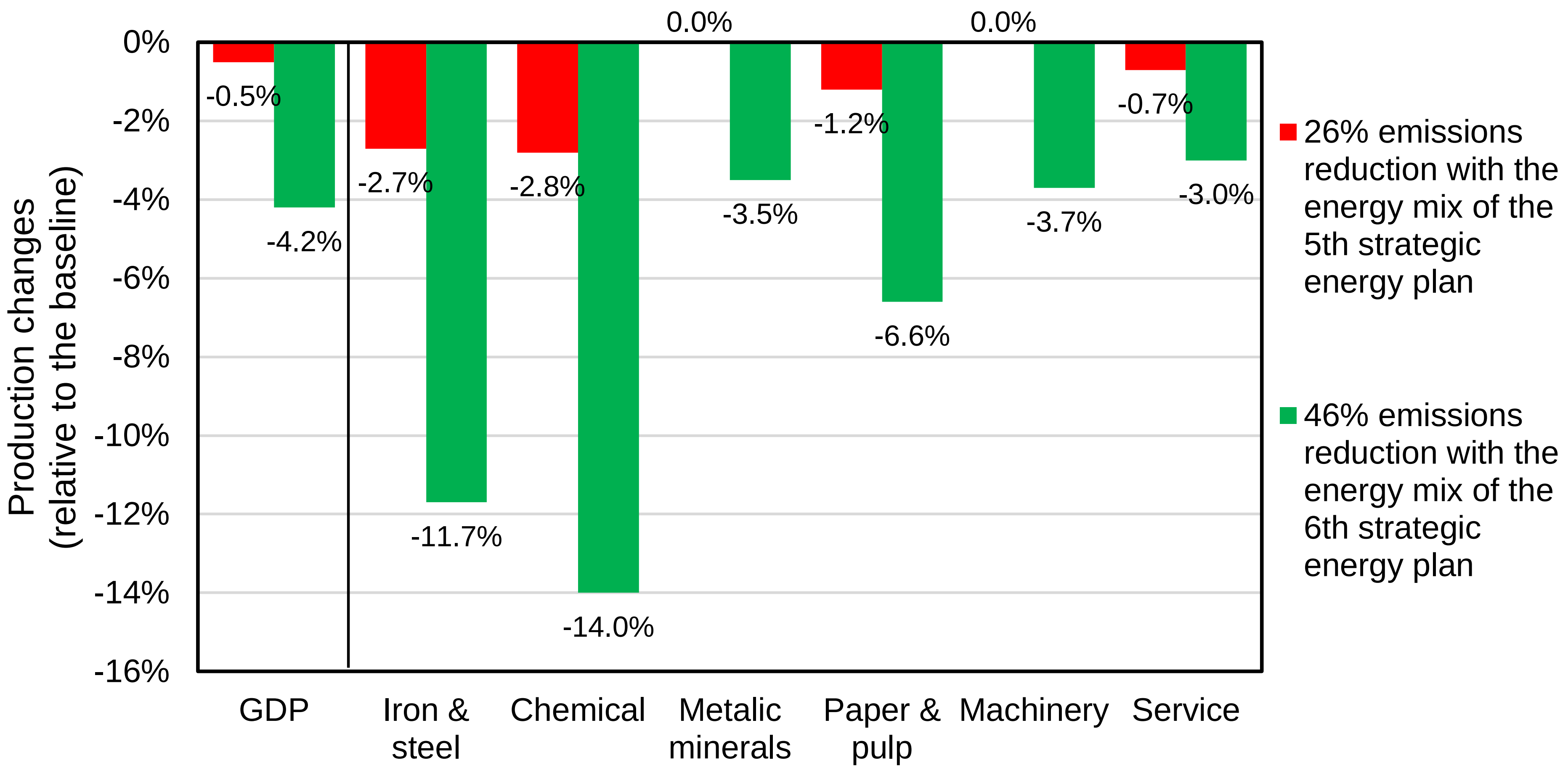
Source) ALPS Int'l Symposium (2022)



Note) The estimations were not conducted for Brazil and Indonesia that have large potentials in emission reductions in LULUCF, due to high uncertainties in costs for LULUCF; and for Iran, due to high uncertainties in the definition of BAU emissions of the NDC.

- **Large differences in MAC for NDCs among countries, and they have potential risks of carbon leakages.**

Sectoral Impacts on Production in Japan due to NDCs



- **For the 46% reduction of the Japan's NDC, the economic impacts on the CO2 intensive sectors, such as iron & steel and chemical sectors, will be much higher than the average impacts, including the impacts of emissions reduction in international competitiveness and the resulting net export.**

Simulation Cases for the impacts of BCA

Cases	**Club***				**Non-Club**	
	Club members	Emission reduction targets	BCA**, ***	Export rebate	Members	Emission reduction targets
NDC	**Europe, US, Japan**	NDC targets (collaborative reductions within Club)	No BCA	No	other countries	NDC targets
CTAX0						**Zero carbon prices**
CTAX0 +BCA EITE			**BCA (EITE)** **against non-club**			
CTAX0 +BCA I&S			**BCA (I&S)** **against non-club**			
CTAX0 +BCA EITE +ExpRebate			**BCA (EITE)** **against non-club**	**Yes**		

Note:
*Emission trading schemes (ETS) is assumed to be available within Club members. (i.e., same carbon prices within the club)
**BCA on "all Energy intensive sectors (EITE)" or "Iron & Steel (I&S) alone " are assumed.
***The imposed import tariffs for BCA are estimated using the difference in carbon prices between club and non-clubs.

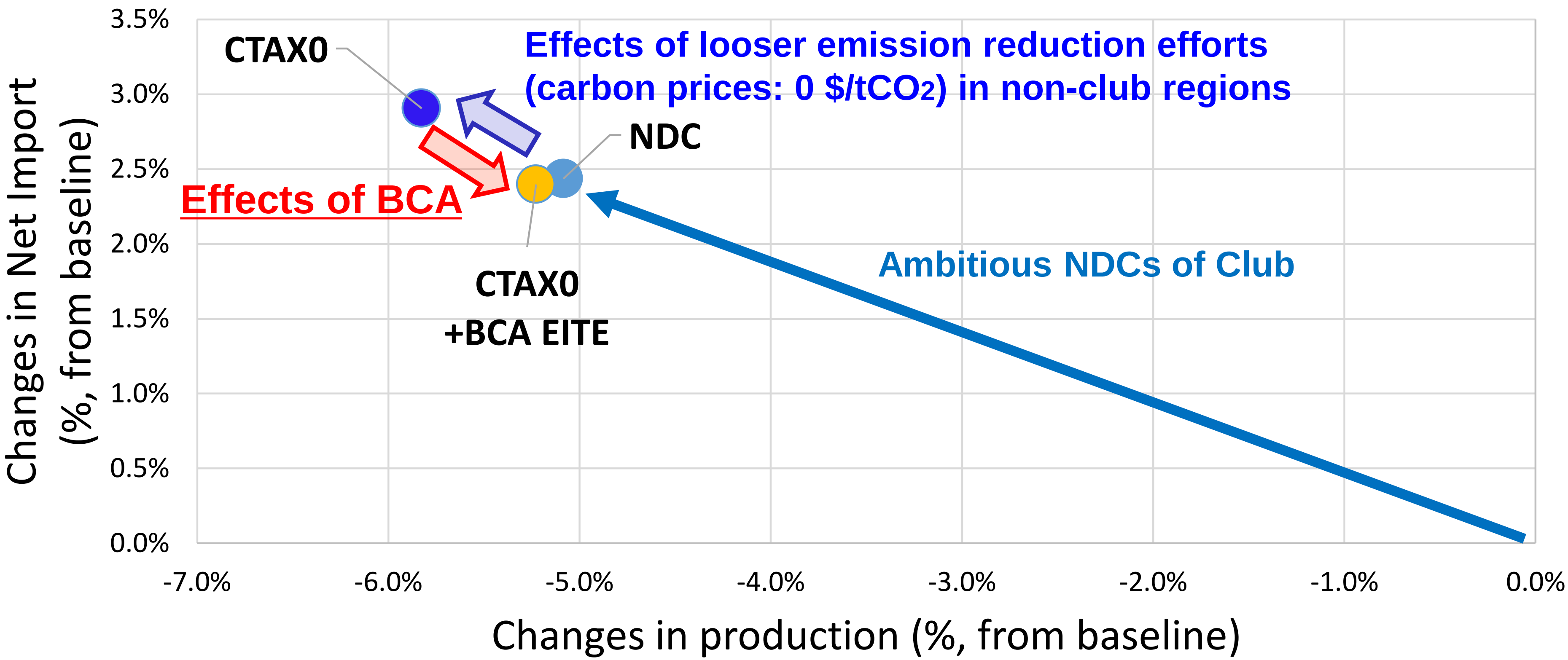
- Baseline GDP and CO_2 emissions are calibrated to those of the current policy scenario of IEA-WEO 2018, in which COVID-19 impacts are not considered.
- “Europe” covers EU and non-EU European countries (UK, Norway, Switzerland, and Iceland).
- EITE={Iron & Steel, Chemical, Non- ferrous metals, Non-metallic minerals, Paper & pulp}.

Source) T. Homma et al., (2021)

Effects of the BCA on international competitiveness (Iron & Steel sector in 2030)

Estimations by using a CGE type, DEARS model

Source) T. Homma et al., (2021)

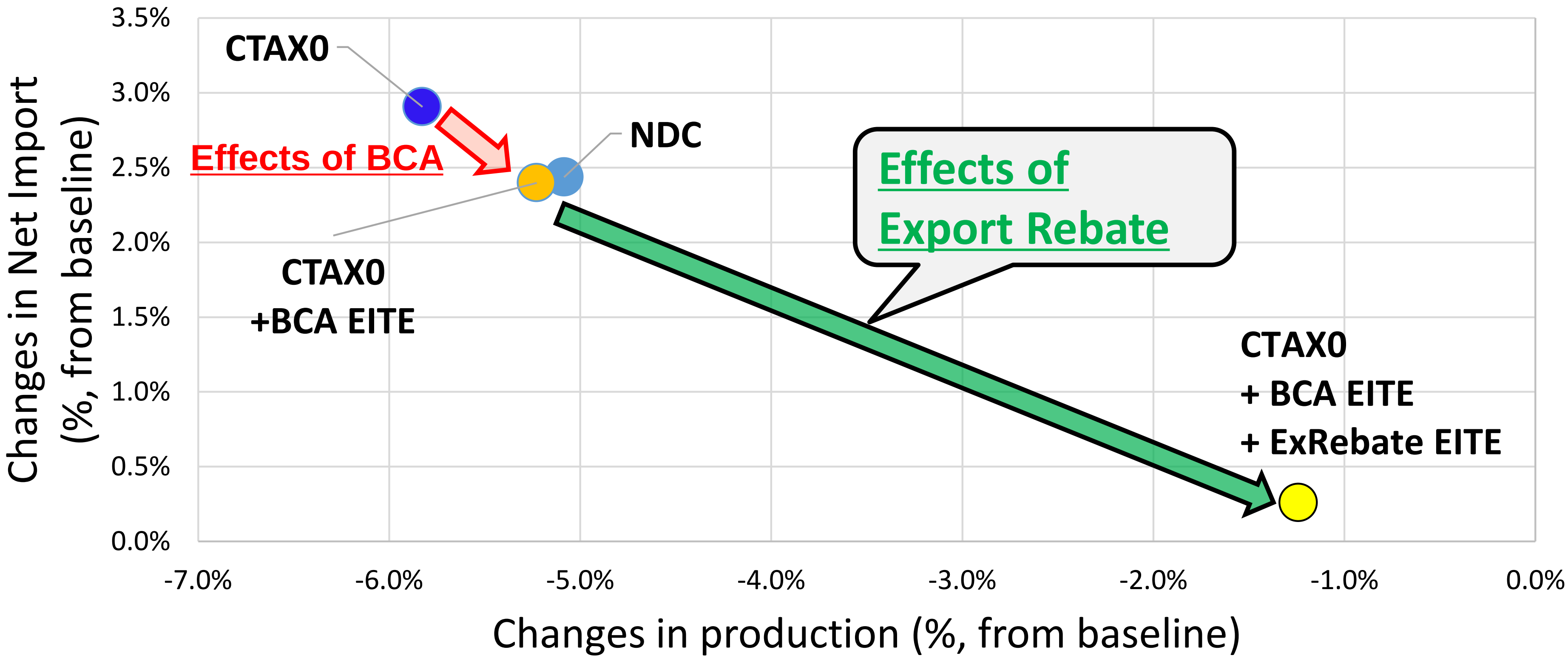


Note: Changes % are normalized using baseline production.

- **The international competitiveness of Club (Europe, US, and Japan) in iron and steel sector (and EITE) will decrease (the productions decrease and net imports increase) under ambitious NDCs of the Club.**
- **BCA will be able to mitigate a part of carbon leakage, but will be limited.**

Effects of the BCA plus Export Rebate on international competitiveness (Iron & Steel sector in 2030)

Estimations by using a CGE type, DEARS model

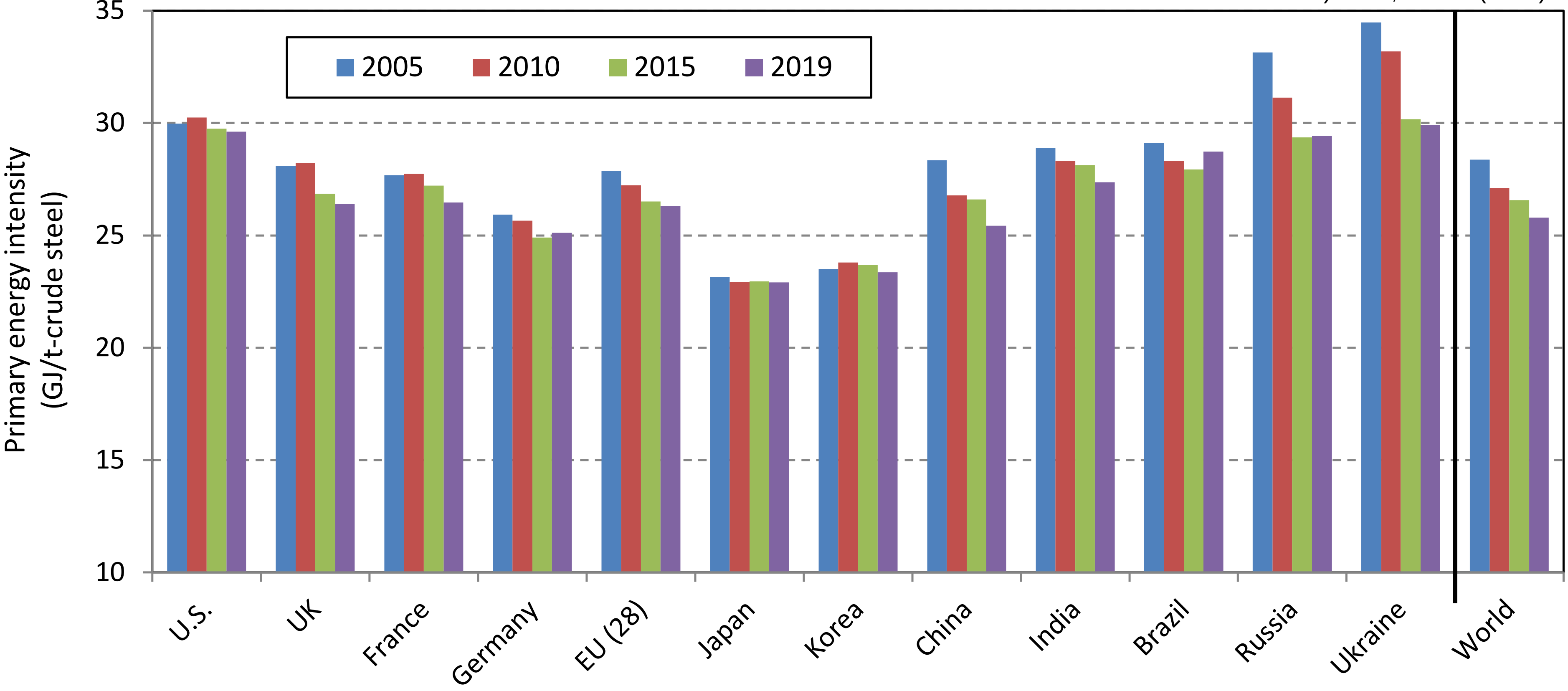


Note: Changes % are normalized using baseline production.

- **Adding export rebates can also alleviate losses of productions and exports. The effects of export rebates in Iron & Steel sector have possibly much higher than BCA limited to imports.**
- **But export rebates possibly have inconsistency with the WTO rule.**

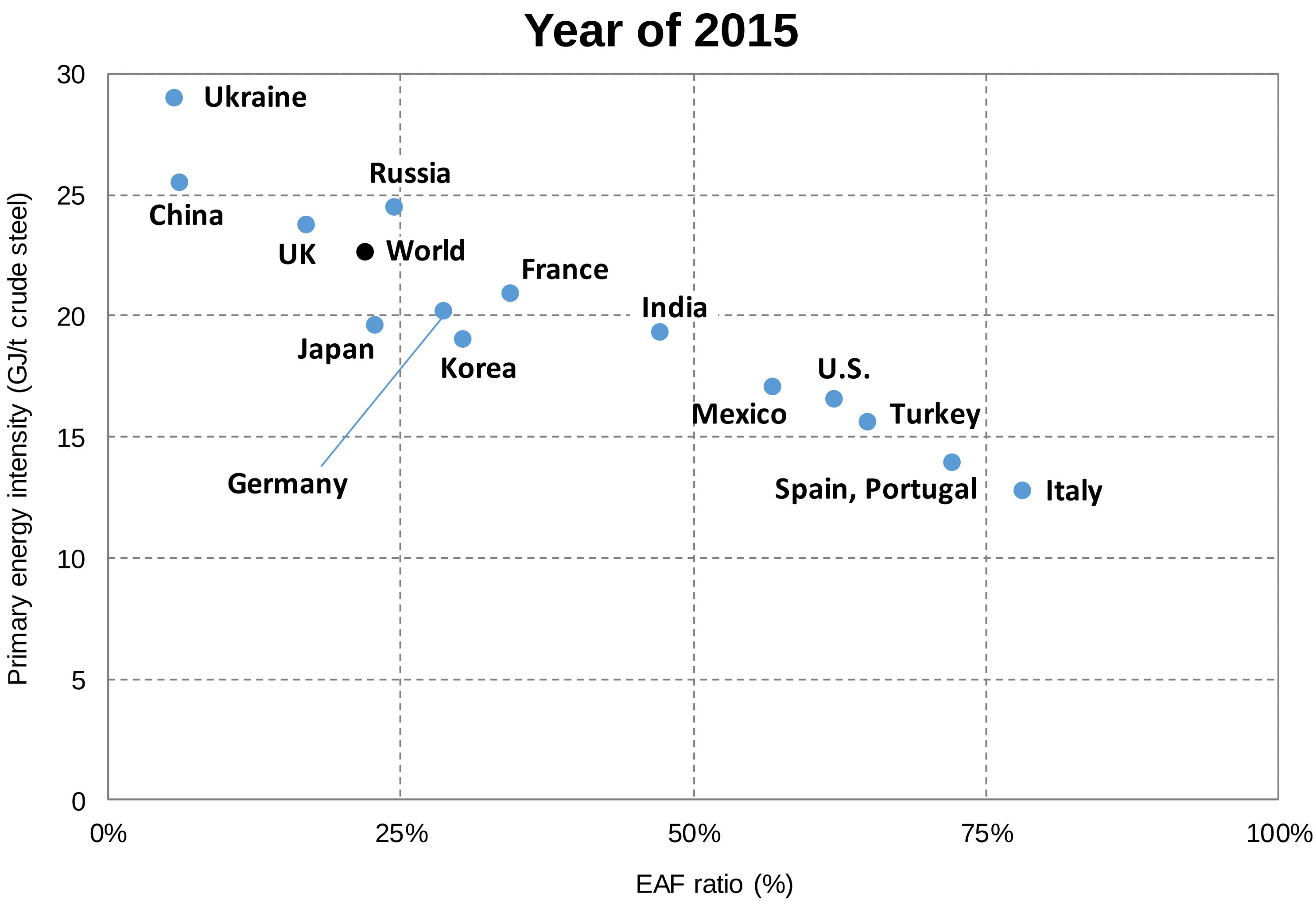
Energy intensity of iron and steel productions through BF/BOF route

Source) RITE, J. Oda (2022)



- **It is very challenging to define and measure implicit carbon prices.**
- **Another method to measure the corresponding to the implicit carbon prices is to measure energy and CO2 intensity embodying in products, which can be considered to be outcomes from implicit carbon prices, and also will be directly the most important for the global emissions.**

Energy intensity of steel sector (BOF+EAF)



- Energy intensity by country depends on EAF ratio rather than the energy (in)efficient conditions.
- On the other hand, the availabilities of scrap steel vary widely across countries.

Conclusions

- **The Government of Japan revised the 2030 emissions reduction target to 46% reductions compared to the 2013 level. Many developed countries also revised their emissions reduction target to be more ambitious ones.**
- **The assessments for the emissions reduction efforts of NDCs are important under a "pledge-and-review" process of the Paris Agreement.**
- **In addition, the assessments of the expected economic impacts of the NDCs including the expected carbon leakages are important in order to obtain the global emissions reduction effects.**
- **Large differences in MAC (carbon prices) for NDCs among countries are estimated, and they have potential risks of carbon leakages.**
- **Use of a BCA can mitigate leakage from the EITE sectors by a third (reducing leakage from 3% to 2%), if the export rebates are not introduced.**
- **Globally coordinated among emission reduction efforts should be pursued.**
- **But the global benchmarking for the resulting CO2 intensity of production processes of each sector or products, which will be achieved by retail prices of final energy etc. including additional efforts of carbon prices, will be more important.**

Appendix

Energy-related Technology Assessment Model: DNE21+
(Dynamic New Earth 21+)

- Systemic cost evaluation on energy and CO_2 reduction technologies is possible.
- Linear programming model (minimizing world energy system cost; with 10mil. variables and 10mil. constrained conditions)
- Evaluation time period: 2000-2100
  Representative time points: 2005, 2010, 2015, 2020, 2025, 2030, 2040, 2050, 2070 and 2100
- World divided into 54 regions
  Large area countries, e.g., US and China, are further disaggregated, totaling 77 world regions.
- Interregional trade: coal, crude oil/oil products, natural gas/syn. methane, electricity, ethanol, hydrogen, ammonia, CO_2
- Bottom-up modeling for technologies on energy supply side (e.g., power sector) and CCUS
- For energy demand side, bottom-up modeling conducted for the industry sector including steel, cement, paper, chemicals and aluminum, the transport sector, and a part of the residential & commercial sector, considering CGS for other industry and residential & commercial sectors.
- Bottom-up modeling for international marine bunker and aviation.
- Around 500 specific technologies are modeled, with lifetime of equipment considered.
- Top-down modeling for others (energy saving effect is estimated using long-term price elasticity.)

- **Regional and sectoral technological information provided in detail enough to analyze consistently.**
- **Analyses on non-CO_2 GHG possible with another model RITE has developed based on US EPA's assumptions.**

- **Model based analyses and evaluation provide recommendation for major governmental policy making on climate change, e.g., cap-and-trade system and Environmental Energy Technology Innovation Plan, and also contribute to IPCC scenario analysis.**

Energy-economic Model: DEARS

An energy-economic model, **DEARS (Dynamic Energy-economic Analysis model with multi-Regions and multi-Sectors)***

- Integration model of a top-down-typed economic module (of computational general equilibrium approach based on international input-output tables) and bottom-up-typed energy systems module
- Intertemporal non-linear optimization model (Maximization of global consumption utility)
- Evaluation time period: up to the middle of this century (10 years steps)
- World divided into 18 regions (US, EU, Japan, China, India,...)
- Non-energy sectors: 16 sectors
- Energy: 8 types of primary energy and 4 types of secondary energy
- Economic module that represents **international economic structures based on input-output tables of GTAP (Global Trade Analysis Project) database**. **The baseline GDP by region/country are calibrated to those of the IEA-WEO2018**.
- Simplified energy systems module
  - ✓ Bottom-up modeling for technologies in energy supply (e.g. , power generation) and CCS (carbon capture and storage)
  - ✓ Primary energy (8 types): coal, crude oil, natural gas, hydro & geothermal, wind, PV, biomass and nuclear
  - ✓ Top-down modeling for energy demand (residential sector: price and income elasticities of demand for energy and income, industrial and transport sectors: price elasticity, linked to the economic module)
  - ✓ Final energy (4 types): solid, liquid and gaseous fuels and electricity

** T. Homma & K. Akimoto," Analysis of Japan's energy and environment strategy after the Fukushima nuclear plant accident ", Energy Policy 62 (2013) 1216–1225*

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.

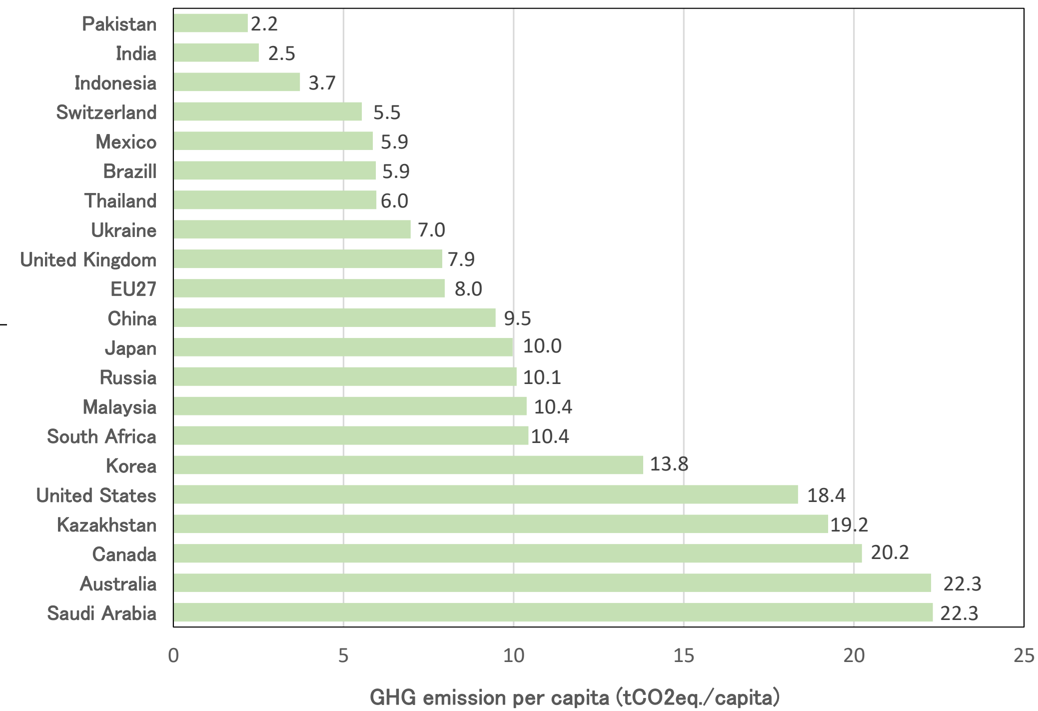
Employed indicators for measuring emissions reduction efforts (2/2)

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.

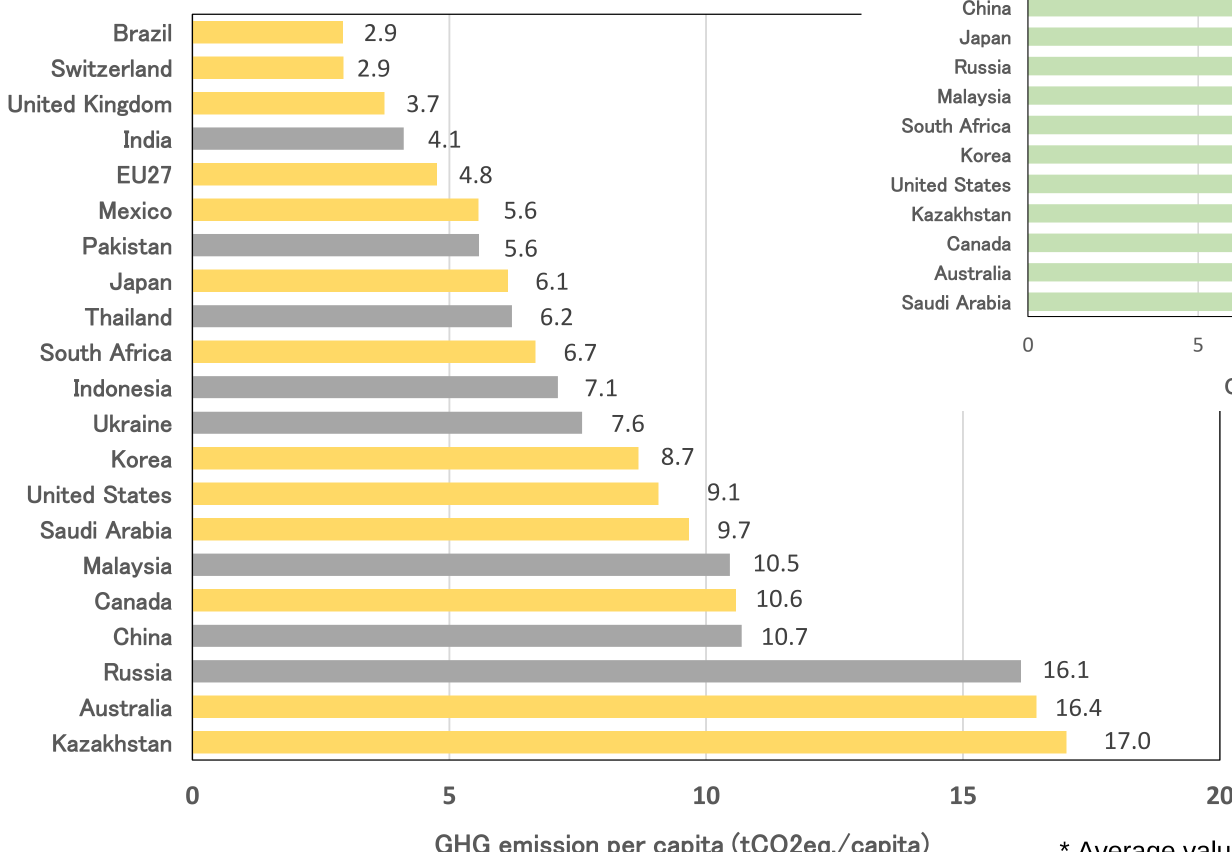
Comparison in GHG emission per capita (2015, 2030)

This indicator is highly dependent on the country's level of economic activity and situation in general.

2015 historical values



NDCs for 2030



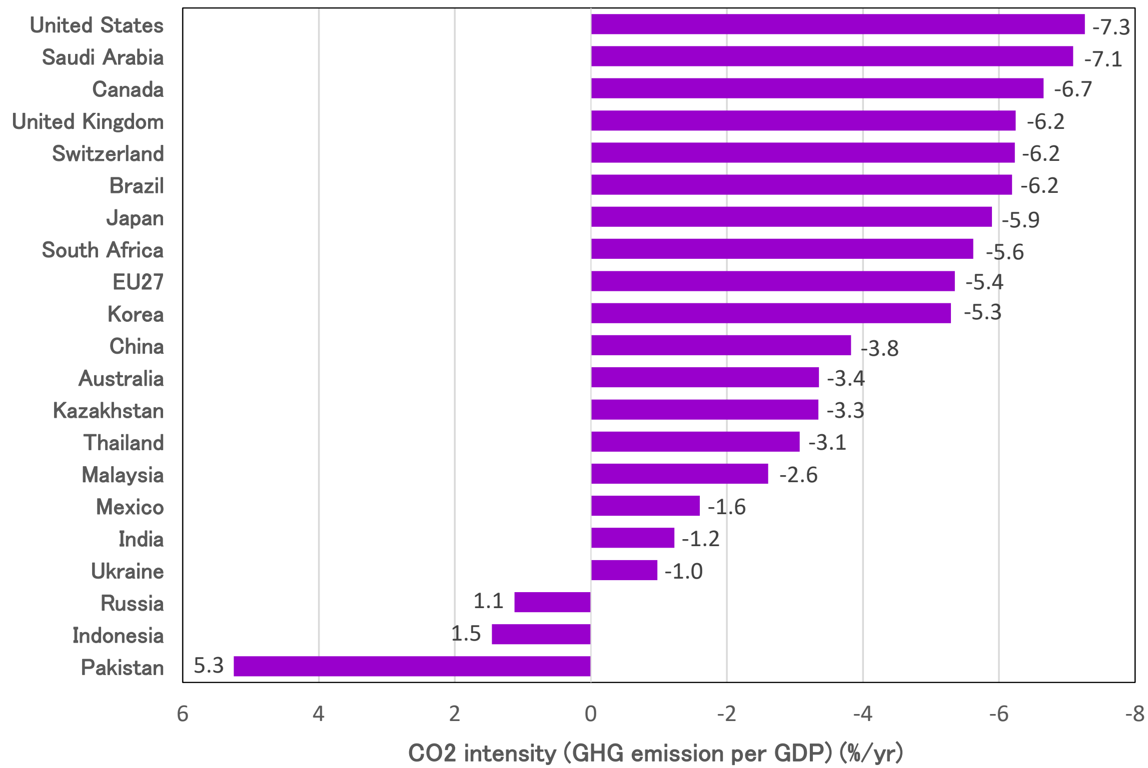
Yellow: GHG emission per capita decreased from 2015;
Gray: GHG emission per capita increased from 2015

* Average values are shown for countries having upper/lower targets.

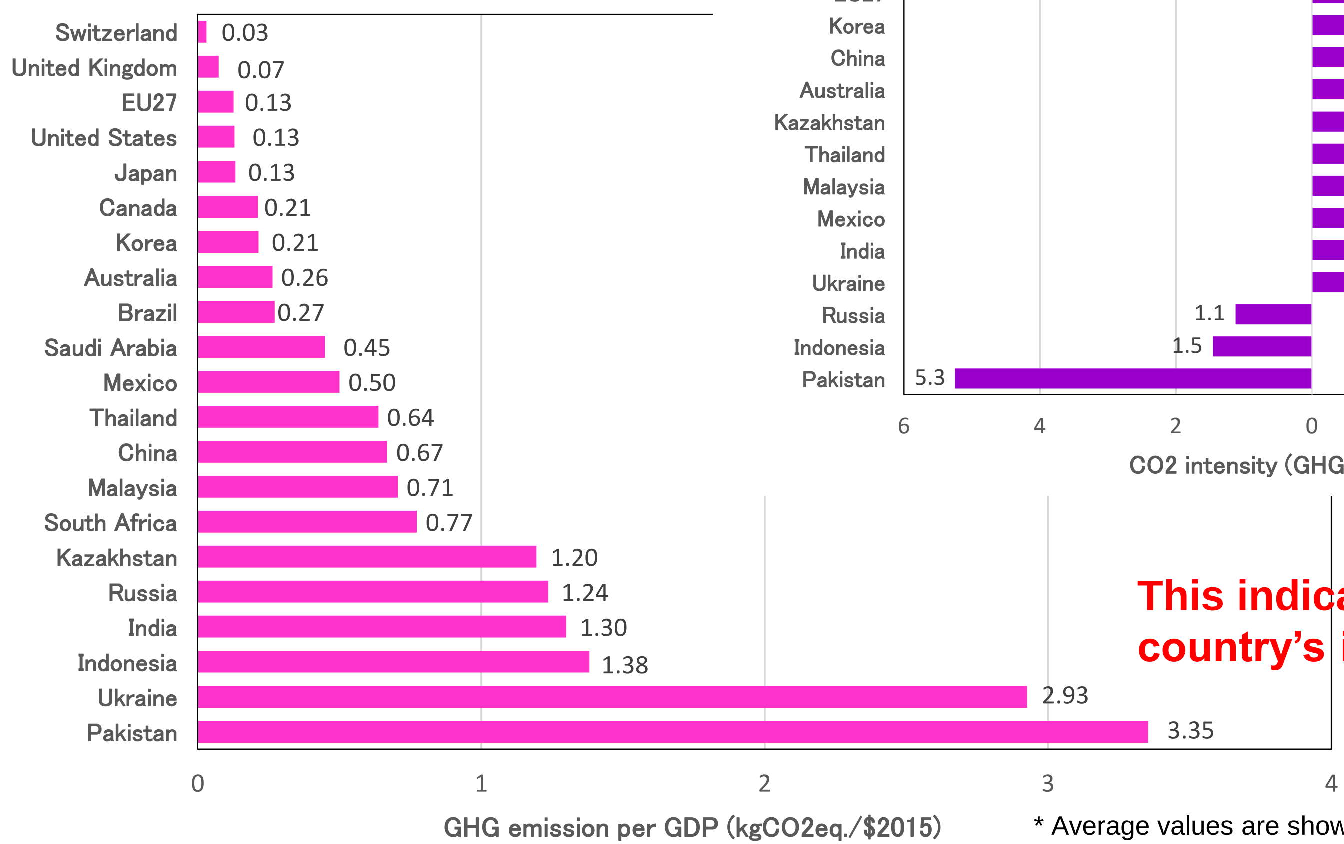
Comparison in GHG emission per GDP (MER) in 2030

GHG emission per GDP (MER) change ratio

2019-2030 (or 2015-2030)



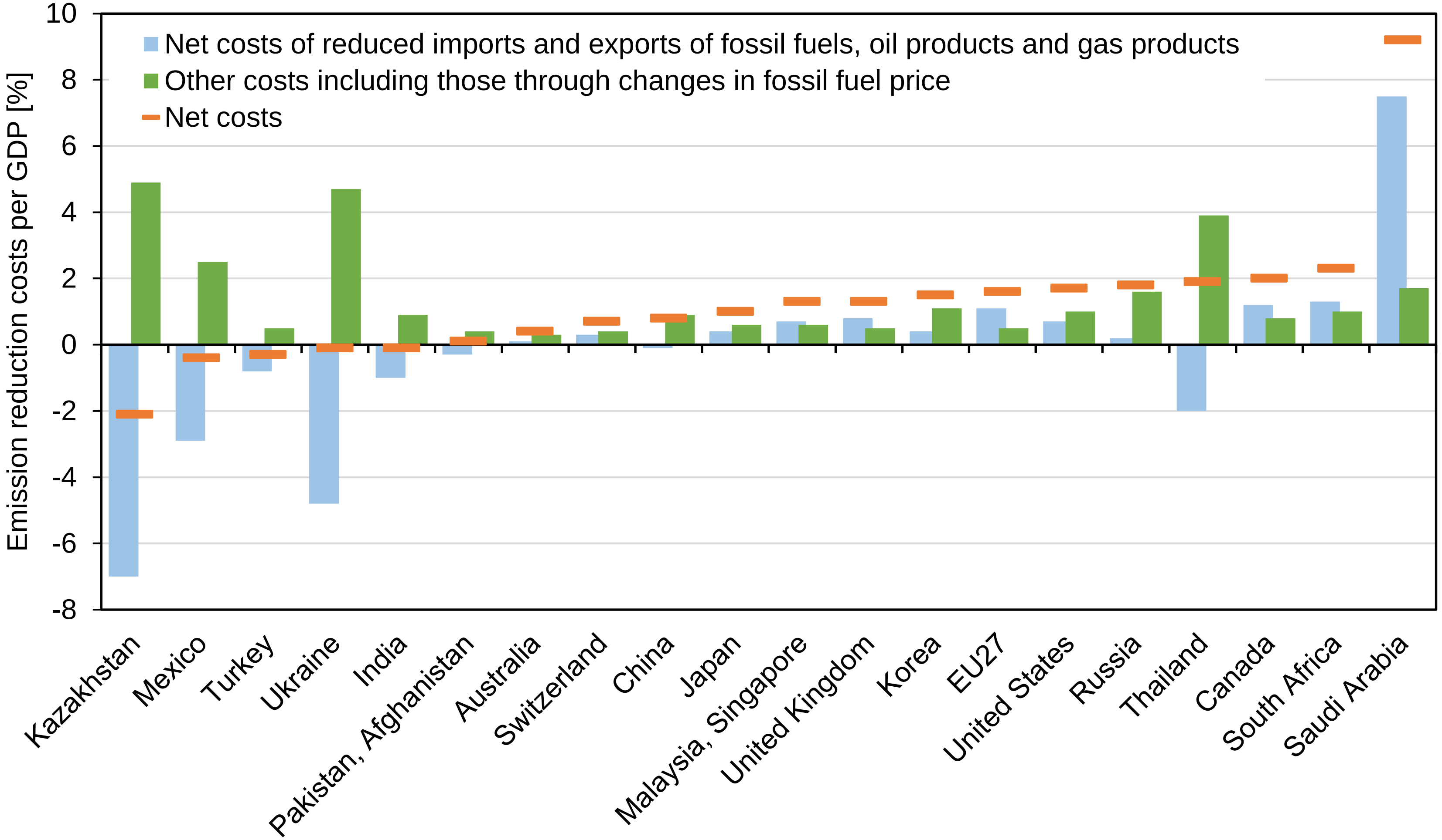
GHG emission per GDP (MER)



This indicator is determined by the country's industrial structure etc.

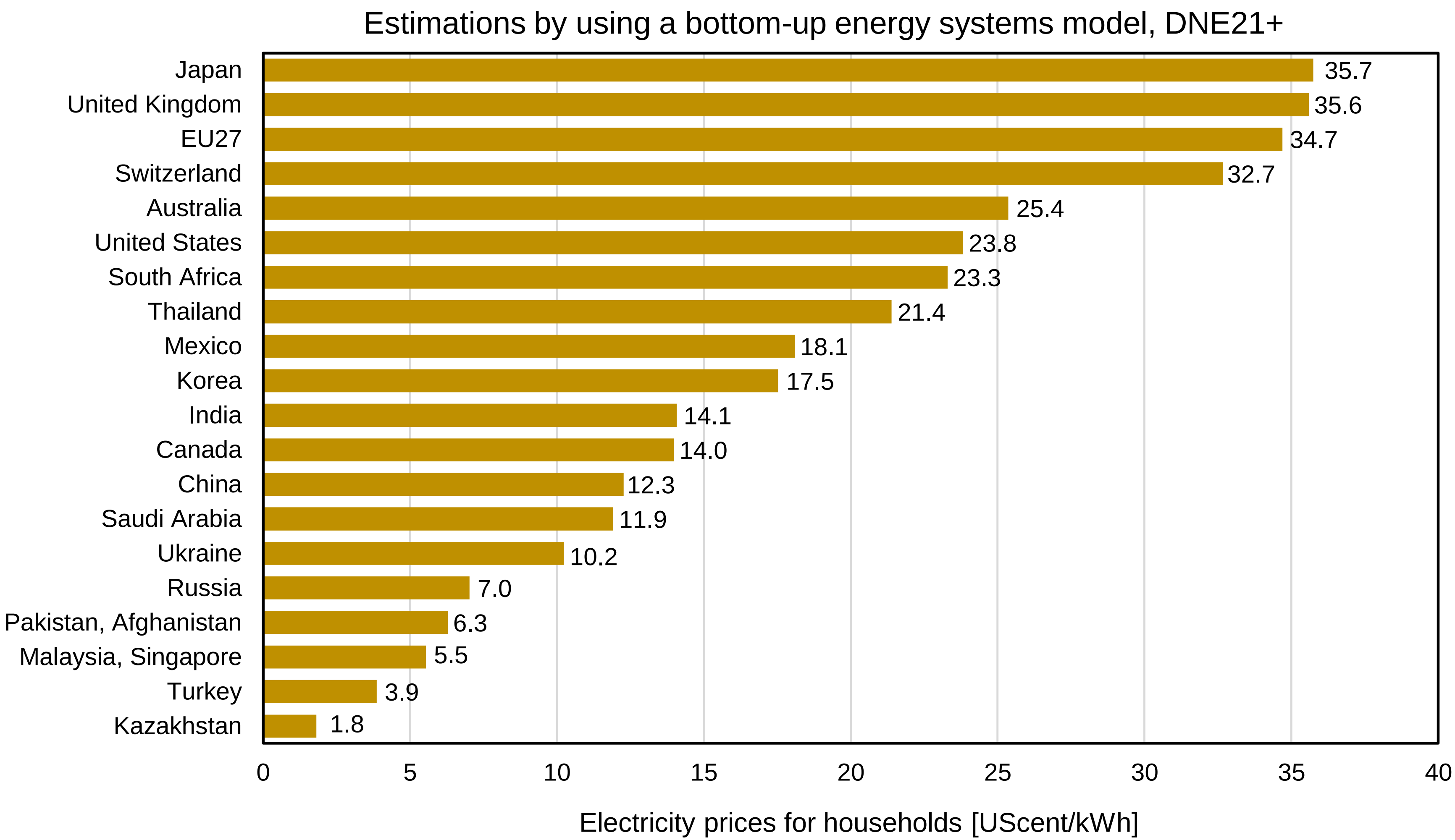
* Average values are shown for countries having upper/lower targets.

Comparisons in emission reduction costs per GDP in 2030 across countries



- ✓ **In developed countries, while the MACs are high, the emission reduction costs per GDP are around 0.5-1.5% since their GDP values are high.**
- ✓ **In oil/gas export countries, the net emission reduction costs are expected to increase (due to sales decrease) as fossil fuels export will decrease along with emission reduction by NDCs. Japan's net cost of imports and exports of fossil fuels will increase driven by the transition from coal to gas, etc.**
- ✓ **Also, the oil/gas export will be shifted from higher MAC countries to lower MAC countries.**

International comparison of retail prices of energy (electricity)



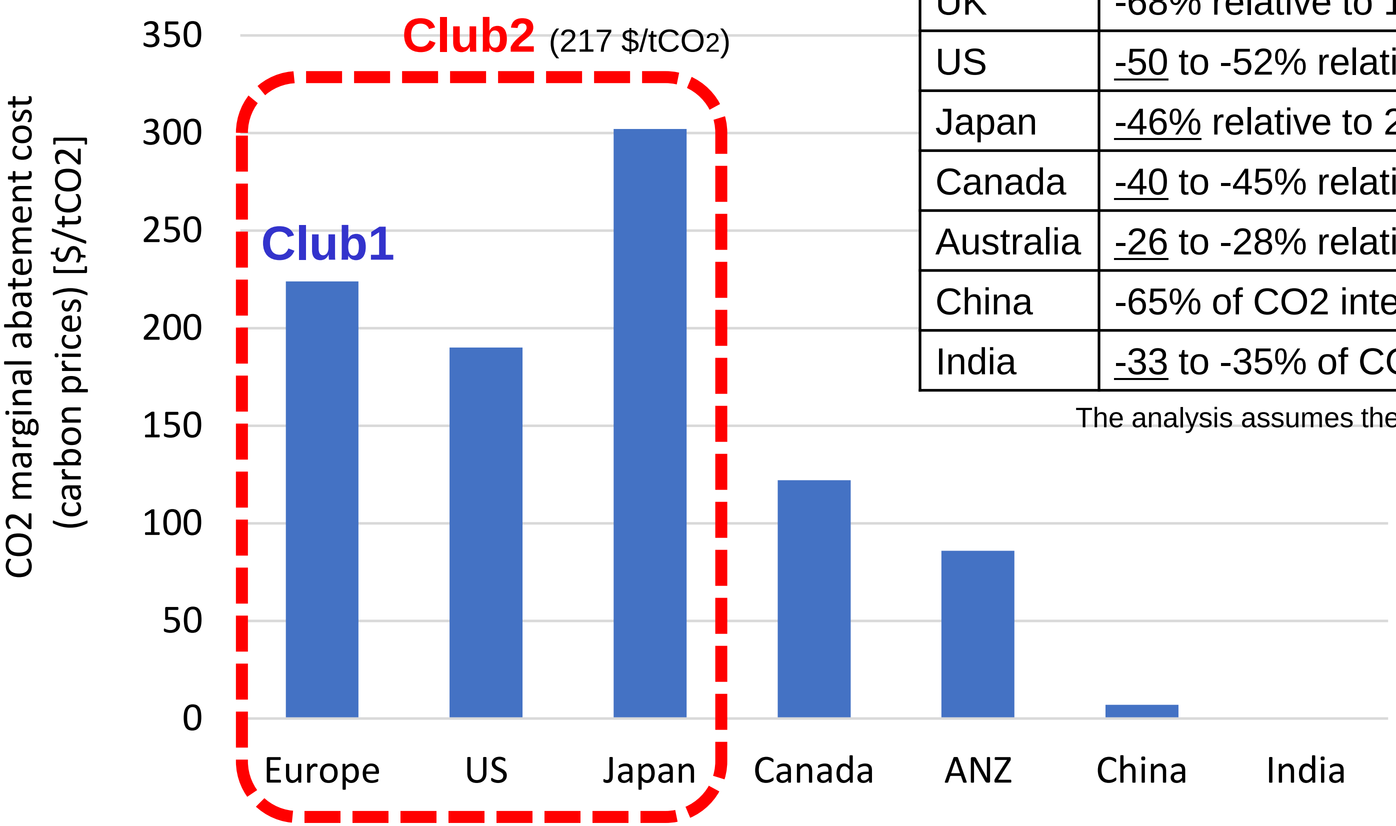
- **Final energy prices including retail prices of electricity will induce low energy consumptions for products and services directly, while carbon prices and emissions reduction costs will induce tha additional effects.**

Carbon Prices of NDCs in 2030

This and the following estimations are conducted by using an energy-economic model, **DEARS.**

	2030 NDCs
EU	-55% relative to 1990
UK	-68% relative to 1990
US	<u>-50</u> to -52% relative to 2005
Japan	<u>-46%</u> relative to 2013 (challenging to -50%)
Canada	<u>-40</u> to -45% relative to 2005
Australia	<u>-26</u> to -28% relative to 2005
China	-65% of CO2 intensity relative to 2005
India	<u>-33</u> to -35% of CO2 intensity relative to 2005

The analysis assumes the lowest targets of emission reductions.



Estimated carbon prices to achieve the NDCs differ greatly among countries.