

# Fair guidance in ratcheting up the national net-zero emission ambitions

LI M.<sup>1</sup>, ZHENG X.<sup>2</sup>, WANG C.<sup>1,\*</sup>

<sup>1</sup> School of Environment, Tsinghua University, Haidian, Beijing, 100084, China

<sup>2</sup> School of Economics and Management, China University of Petroleum-Beijing, Changping, Beijing, 102249, China

\*corresponding author:

e-mail: canwang@tsinghua.edu.cn

**Abstract.** National net-zero pledges have brought the Paris Agreement temperature target within reach, yet they still need a boost. Current evaluations and analyses of net-zero targets have fallen short in equity. We use a transparent and multidimensional approach to go beyond the long-standing dispute of detailed equity definitions and assess the Paris Agreement compatibility of national net-zero targets from a general equity perspective. We use the allowed national emissions as a reference to incentivize countries to increase their targets. If countries follow a linearly increasing ambition level of Nationally Determined Contributions (NDCs) to net-zero commitments and then remain on this path, global warming will be limited to about 1.8 °C (high NDCs) or -1.9 °C (low NDCs) by 2100. Our work provides essential information for reviewing and advancing net-zero commitments and promoting the convergence of national actions towards the 1.5 °C goal.

**Keywords:** Net-zero pledges; equity; Paris Agreement

## 1. Introduction

Since the Paris Agreement aimed to “achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century” (UNFCCC, 2015), an increasing number of countries have pledged to achieve net zero emissions in the future. These national net-zero pledges narrowed the emission gap, yet they are still not ambitious enough to achieve 1.5°C or 2°C temperature control targets (Meinshausen et al., 2022) and no country’s existing short-term policies are consistent with the announced net-zero targets pledges (Hoehne et al., 2021). Most of the current research used the integrated assessment model (IAM) to assess the national net-zero emission time. Yet it is inherently unfair to adopt a unified marginal abatement cost solution in a world where responsibilities, capabilities, needs, and vulnerabilities are highly unevenly distributed. Employing equitable effort sharing to review national net-zero pledges is critical to promote climate actions. Moreover, it is necessary to get out of the dilemma of discussing specific allocation schemes and explore how equitable effort sharing in general will facilitate an ambitious international mobilization.

In this work, we evaluate the national net zero pledges from an equity perspective and explore possible pathways for intensifying national ambitions and meeting the Paris Agreement 1.5 °C target. Concentrating on the policy-related divergence derived from operationalizing equity criteria and their indicators, we select 15 prevailing allocation schemes adapted from 4 equity principles and develop 1542 sub-schemes by changing the parameters to establish a multidimensional effort-sharing model. We use the range of model allocations as a reference for allowable national emissions and quantitatively analyze the national reduction ambitions. We show that nearly half of the national net-zero pledges are consistent with the 1.5 °C target, significantly improving compared with the NDCs. With the current commitments, as long as countries linearly increase the NDCs ambition to net zero and then remain on this path, the global warming limit could reach 2 °C by 2100. This study provides insight for policymakers into a quantitative review of the national net-zero targets. It can be used to guide the pledge update under the five-year global stocktake mechanism.

## 2. Methods

### 2.1. Construction of the global emission equitable allocation model

In this research, we concentrate on the policy-related divergence derived from operationalizing equity criteria and their indicators. 1542 sub-schemes are developed by varying parameterizations of 15 prevailing allocation schemes, which are adapted from the 6 equity categories in Intergovernmental Panel on Climate Change’s (IPCC’s) Fifth Assessment Report (IPCC-AR5). This allocation system is then imposed on the global emissions path and the overall national emission allocation space is obtained under 1.5°C-consistent scenarios. We further raise possible emission paths to intensify reduction actions, and link the emission pathways to a potential temperature increase at the end of this century relative to pre-industrial levels by performing a linear regression.

**Table 1.** Categorizations and descriptions of equity dimensions and allocation schemes

Abbrviate	Schemes (No. of sub-schemes) <sup>§</sup>	Equity Dimensions
Resp.	Historical Responsibility (10)	Responsibility or(and) Capability & Sustainable Development (Basic) Needs*
Cap.	Economic Capability (6)	
Resp. & Cap.	Responsibility & Capability (300)	
GDR	Green Development Rights (50)	
HDI	Human Development Index (150)	
EqPC	Equal Per-Capital Emissions (1)	Equal Per-capita (Cumulative) Emissions
C&C	Contraction and Convergence (5)	
CDC	Common but Different Contractions (5)	
EPCCE <sup>†</sup>	Equal Per-Capita Cumulative Emission (25)	
M-S	Multiple Stages (150)	
S-N	South-North Dialogue (100)	Staged Approach
GF	Grandfathering (3)	
CIC	Carbon Intensity Convergence (2)	
MCA	Multiple Criteria Approach (720)	
PS	Preference Score (15)	

\* Responsibility, Capability, and their combinations are located at three positions in the equity frame. They are introduced as a single category here because this combination is typically studied together in the previous literature. <sup>†</sup> Equal Per Capita Cumulative Emissions (EPCCE) is a combination of responsibility and equality. It is categorized into the Equal Per-capita (Cumulative) Emissions dimension because it is a correction of egalitarianism. <sup>‡</sup> Current Emissions dimension is constructed from the Staged Approach since sovereignty is a focal principle and is highlighted. The schemes based on

status-quo rights are classified into this dimension. The Multiple Criteria Approach (MCA) belongs to this category because it considers multiple criteria related to national circumstances. <sup>§</sup> Depending on the number of parameter variants.

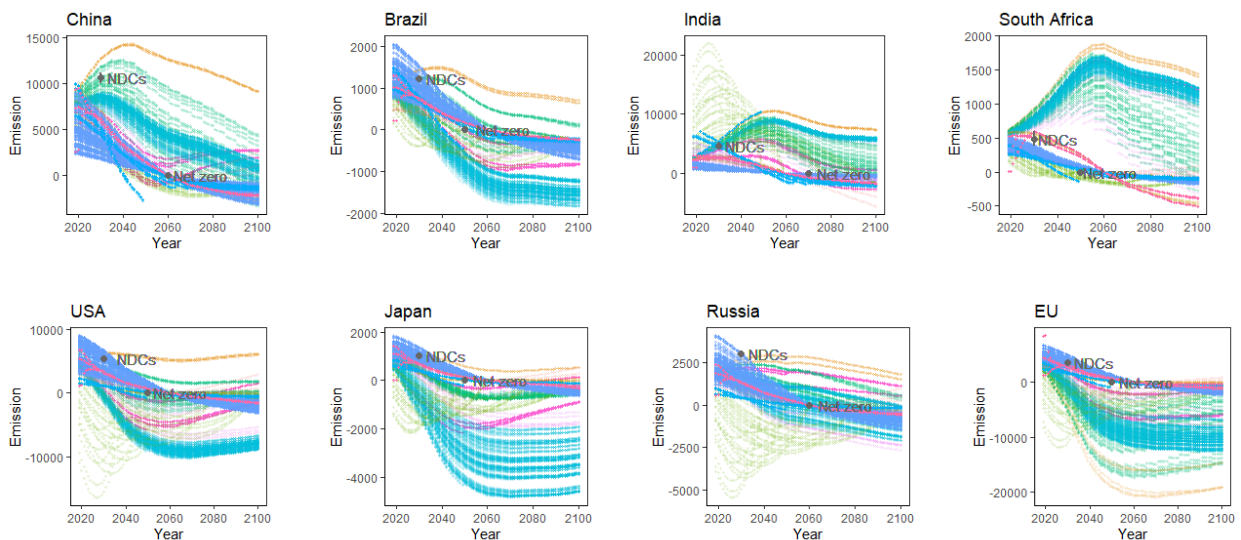
## 2.2. Assessment of the end-of-century temperature rise

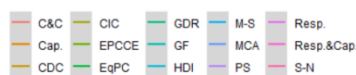
We select 524 scenarios with complete CO<sub>2</sub> emission data every ten years from 2010 to 2100 from the IPCC-AR5 database. We extract the CO<sub>2</sub> emission levels every ten years from 2010 to 2100 and the warming in 2100 relative to the pre-industrial period and perform linear regression to obtain the relationship. This relationship links the emission pathways to a potential temperature increase at the end of this century relative to pre-industrial levels. This method is based on multiple models and scenarios from a database of integrated models, enabling a rapid estimate of the temperature resulting from cumulative emissions.

## 3. Results

### 3.1. National emissions derived from the multidimensional effort-sharing model

The national emission budget has a large range due to differences between and within the prevailing schemes, which is confirmed by the increasingly skewed distributions of the sub-schemes. Despite scale differences, most allocations show similar overall emission trends for the major countries. However, the outcomes of all schemes are more dispersed for the major developing countries than the major developed countries. Brazil, the US, the EU, and Japan must start reducing emissions immediately to achieve the Paris Agreement 1.5 °C target and reach net-zero emissions around the mid-century. In contrast, China, India, and South Africa still have room for increasing emissions and need not reach net zero by the end of the century.





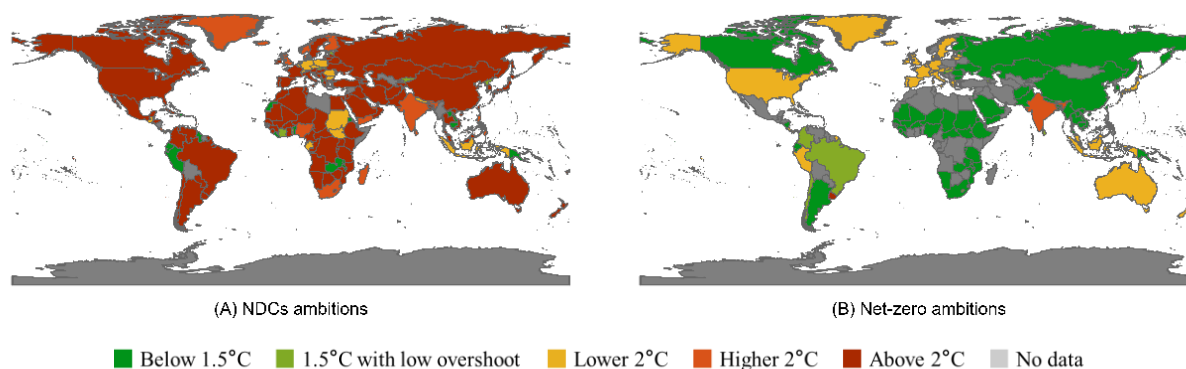
**Figure 1. The range of carbon emission allocations of major emitters in 2019-2100 under equitable effort-sharing (Mt CO<sub>2</sub>e). Each semi-transparent line represents a single sub-scheme allocation, and different colors represent different prevailing allocation schemes. Darker colors indicate a higher frequency of sub-schemes. The solid black lines and dots represent the national NDCs (or the range of NDCs) and net-zero pledges.**

### 3.2. Net-zero time sensitive to different 1.5 °C pathways

The net-zero time for most countries/regions, including the EU, the United States, and Japan, is similar to the global net-zero time for the three pathways, indicating that the higher the short-term emissions, the later the net-zero time occurs. However, the pattern differs for different countries. The median net-zero time of China, India, and Russia is 33 years, >20 years, and 18 years earlier, respectively, for the 1.5 °C pathway with high overshoot than for the 1.5 °C pathway with no or low overshoot. Some countries even reach the net-zero time earlier than the below 1.5 °C pathway. For example, India reaches net zero at 2078-2081 in the 1.5 °C pathway with high overshoot but does not reach net zero until the end of this century under the other two pathways. The median net-zero times for BASIC (Brazil, South Africa, India, and China), ASIA, and OPEC occur >31, 8, and >23 years earlier, respectively, in the 1.5 °C pathway with a high overshoot than in the below 1.5 °C pathway.

### 3.3. The ambition of national targets increased from NDCs to net-zero

The countries' reduction ambitions generally increase dramatically from NDCs to net-zero pledges. Nearly half (91 out of 189) of the national net-zero ambitions are in line with the global warming target of below 1.5 °C. However, the net-zero pledges of the EU, Japan, the US, Australia, and New Zealand (32 out of 189) are only in line with the lower 2 °C pathway; the net-zero commitment of India (1 out of 189) is in line with higher 2 °C pathway, leaving room for further improvement. Although the net-zero targets of major emitting countries and regions, such as the EU, the US, and Japan, are generally met earlier than or similar to the global timeframe, these countries/regions should undertake faster mitigation actions following the benchmark emission path and continue to increase their efforts. The EU should be 17 (11-20) years ahead of schedule, Japan should be 17 (12-21) years ahead of schedule, the US needs to be 15 (8-19) years ahead of schedule, and China should be 4 (-34-22) years ahead of schedule.



**Figure 2. Comparison of (A) national NDC ambitions and (B) net-zero efforts to reach the Paris Agreement temperature goal. Shades from green to red represent emission reduction efforts in line with global temperature rises below 1.5 °C, 1.5 °C with a low overshoot, less than 2 °C, higher than 2 °C, and above 2 °C, respectively. Grey indicates that the country has not yet proposed an NDC or net-zero target.**

## 4. Discussion

Since current net-zero pledges remain vague and have been delayed in many cases, the time window for achieving the 1.5 °C targets is getting narrower, and the target could be missed (UNEP, 2021). The latest IPCC Sixth Assessment Report (IPCC, 2022) shows that all mitigation pathways to limit warming to 1.5 °C with no or limited overshoot must achieve net-zero CO<sub>2</sub> emissions in the 2050s. In addition, pathways that could

limit warming to 2 °C would result in a 50% reduction in emissions by the 2040s and net-zero CO<sub>2</sub> emissions by the 2070s. Net-zero GHG emissions are currently necessary for achieving the Paris Agreement temperature target, yet, they are insufficient (Tanaka & O'Neill, 2018). However, the Paris Agreement does not advocate the indiscriminate adoption of net-zero emissions targets in all countries (Fankhauser et al., 2022). It stresses the need for a just transition, emphasizing that net-zero emissions should be achieved equitably and in the

context of sustainable development and poverty eradication and that developing countries may require more time. Our research quantitatively supports this concern from an equity perspective, showing the need for emerging and developed economies to adopt net-zero targets ahead of the world.

## References

- Fankhauser, S., Smith, S. M., Allen, M., Axelsson, K., Hale, T., Hepburn, C., Kendall, J. M., Khosla, R., Lezaun, J., & Mitchell-Larson, E. (2022). The meaning of net zero and how to get it right. *Nature Climate Change*, 12(1), 15-21.
- Hoehne, N., Gidden, M. J., den Elzen, M., Hans, F., Fyson, C., Geiges, A., Jeffery, M. L., Gonzales-Zuniga, S., Mooldijk, S., Hare, W., & Rogelj, J. (2021). Wave of net zero emission targets opens window to meeting the Paris Agreement. *Nature Climate Change*, 11(10), 820-+.
- IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. <https://doi.org/10.1017/9781009157926>
- Meinshausen, M., Lewis, J., McGlade, C., Gütschow, J., Nicholls, Z., Burdon, R., Cozzi, L., & Hackmann, B. (2022). Realization of Paris Agreement pledges may limit warming just below 2° C. *Nature*, 604(7905), 304-309.
- Tanaka, K., & O'Neill, B. C. (2018). The Paris Agreement zero-emissions goal is not always consistent with the 1.5° C and 2° C temperature targets. *Nature Climate Change*, 8(4), 319-324.
- UNEP. (2021). *Emissions gap report 2021* (UN Environment Programme, Issue).
- UNFCCC. (2015). *Adoption of the Paris Agreement* (No. FCCC/CP/2015/L. 9/Rev. 1, 21932 ).