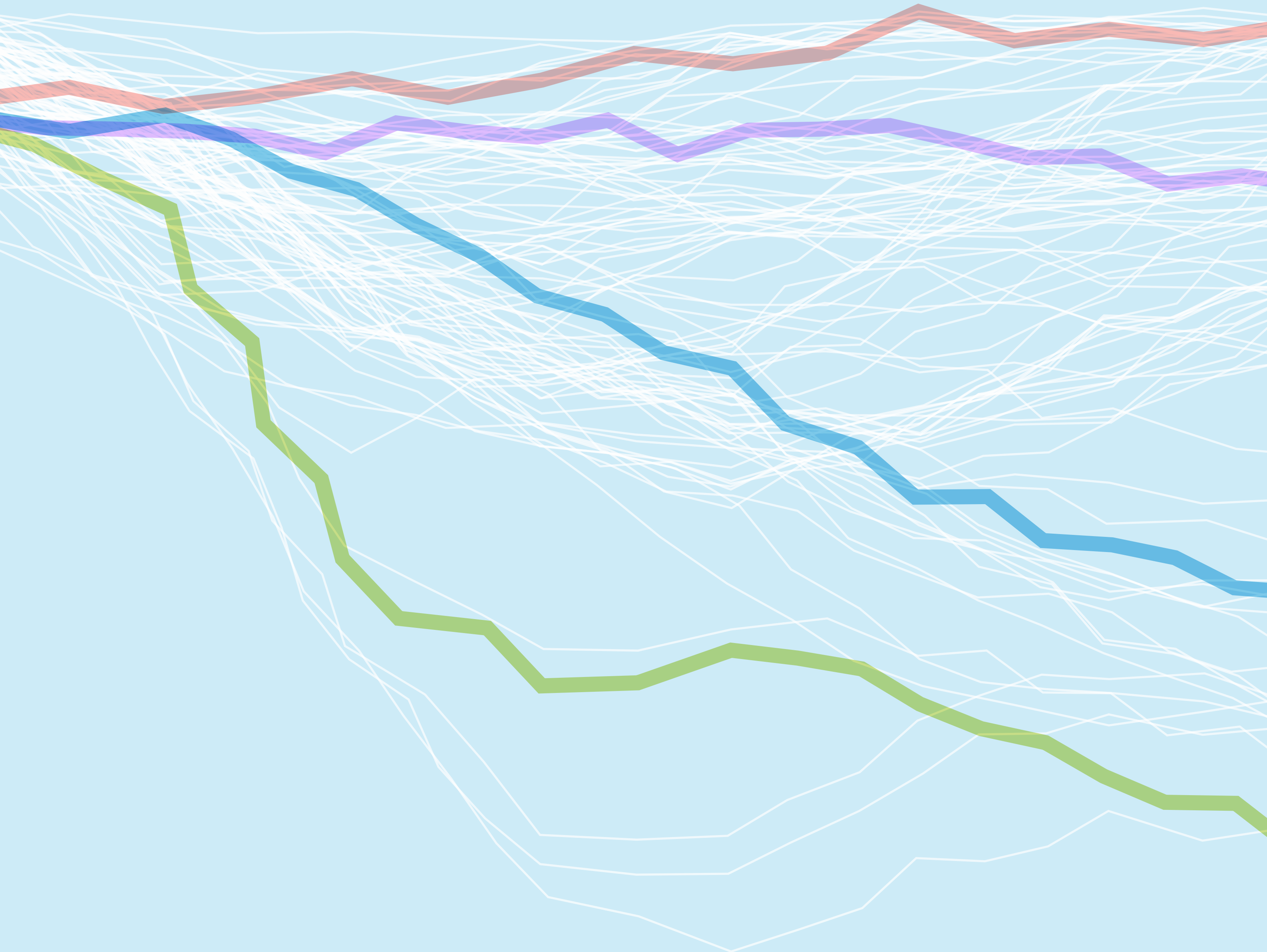

Holding the course in a shifting world

Annual Net-Zero Report 2025

ELEVATE
supporting international climate policy

PBL Netherlands Environmental Assessment Agency

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PBL Netherlands Environmental Assessment Agency is the national institute in the Netherlands for strategic policy analysis in the fields of environment, nature and spatial planning. PBL plays an important role in international assessment of global environmental change. The department of Global Sustainability at PBL uses the GLOBIO and IMAGE models to analyse the effects of global environmental challenges such as biodiversity loss and climate change on society. The team involved in the Integrated Model to Assess the Global Environment (IMAGE) produces scenarios of climate policy and climate change in terms of energy and land use and emissions of greenhouse gases. The IMAGE team has been involved in several European research projects and plays a key role in the development of scenarios for climate change assessment. PBL researchers play an active role in various international assessments, including those of the Intergovernmental Panel on Climate Change (IPCC), UNEP's Global Environmental Outlook (GEO), and the Global Land Outlook. PBL is part of many relevant scientific networks, including the Integrated Assessment Modelling Consortium (IAMC), the Global Carbon Project (GCP) and the Energy Modelling Forum (EMF). The organisation has extensive experience on advising policymakers on climate policy, including the European Commission and the government of the Netherlands.

Glossary

Current Policies

Current policies are defined as legislative decisions, executive orders, or their equivalent in order to mitigate greenhouse gas emissions (GHG). This does not include publicly announced plans or strategies (e.g. Nationally Determined Contributions – NDCs), but does include officially implemented policies to achieve such plans or strategies. The Current Policies (CPs) scenario in this work reflects the implementation of current policies at the national level as included in the list of high impact policies.

Nationally Determined Contributions (NDCs)

Nationally Determined Contributions (NDCs) is the term adopted by the United Nations Framework Convention on Climate Change (UNFCCC) where countries that have joined the Paris Agreement outline their plans for reducing their greenhouse gas emissions. Each country is responsible for preparing, communicating, and maintaining the respective NDC that it intends to achieve. The NDC scenario in this work reflects the implementation of countries' unconditional NDCs (i.e. pledges that have no conditions attached).

Net-Zero Emissions and Long-Term Strategies

According to the Intergovernmental Panel on Climate Change (IPCC), 'net-zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period' (IPCC, 2018). In this work, the Long-Term Strategies (LTS) scenario reflects the implementation of the net-zero pledges that have been announced since the Conference of Parties (COP26) in Glasgow, in 2021.

Paris Climate Goal

Article 2 of the Paris Agreement aims to keep the global mean temperature increase to well below 2 °C (above pre-industrial levels) and pursue efforts to limit the increase to 1.5 °C. In this report, for well below 2 °C we used a limit to greenhouse gas emissions consistent with a 67% probability of staying below 2 °C, equivalent to a likely temperature outcome around 1.7-1.8 °C. For 1.5 °C, we look at scenarios that are expected to be below 1.5 °C by the end of the century with no or limited overshoot.

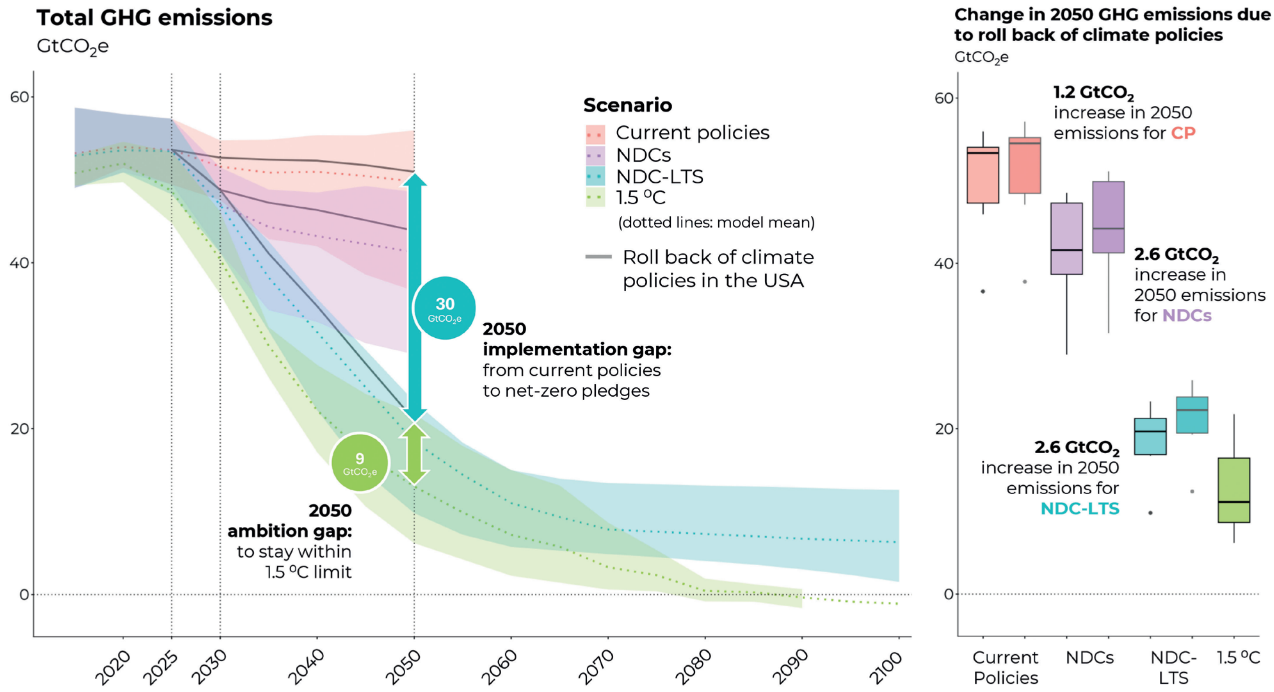
Abbreviations

AR6	6th IPCC Assessment Report
CDR	Carbon Dioxide Removal
COP	Conference of Parties
CO_2e	CO_2 equivalents
CPs	Current Policies
DLS	Decent Living Standards
ESABCC	European Scientific Advisory Board on Climate Change
GHGs	Greenhouse gases
GST	Global Stocktake
GWP	Global Warming Potential
IAMs	Integrated Assessment Models
IMAGE	Integrated Model to Assess the Global Environment
IPCC	Intergovernmental Panel on Climate Change
LTS	Long-Term Strategy
NDCs	Nationally Determined Contribution
SDG	Sustainable Development Goals
UNFCCC	United National Framework Convention on Climate Change

Contents

List of Figures

Main Findings



Global GHG emission pathways under various scenarios

The ELEVATE Annual Net-Zero Reports aim to provide policymakers with a clear, evidence-based understanding of where global efforts currently stand regarding achieving these goals, and how national and international climate policies can be strengthened to meet net-zero targets. This report specifically focuses on the current policies and new NDCs and long-terms goals vis-a-vis the need to reach net-zero emissions mid-century.

Key findings include:

- Current policies and NDCs still fall short of what is needed to meet the Paris Agreement. By the middle of the century, the emissions gap between current policies and trajectories consistent with a 1.5 °C pathway is around 39 $GtCO_2e$. The U.S.' withdrawal from the Paris Agreement and the rollback of domestic climate policies could lead to an increase of approximately 1.2 $GtCO_2e$ in 2050 current policies and 2.6 GtCO2 in 2050 when taking into account NDCs and long-term strategies, compared to last year's assessment.

- While views on what constitutes fair and feasible reduction targets differ, it is still possible to derive a range of 2035 targets based on equity principles and global climate goals. In many cases, such targets would require strengthening of currently proposed NDCs.

- International cooperation is essential for meeting climate goals. The current geopolitical situation and trade barriers could slow down the climate transition.

1. Introduction

Nearly all countries around the world have agreed to reduce greenhouse gas emissions to limit global temperature increases, with an ultimate aim to reach net-zero within the next decades. This edition is published during a time of increasing geopolitical tensions, making progress towards the climate goals more difficult. Meanwhile, the past year has also shown increased and more severe climate impacts, including heatwaves and other extreme weather events. These impacts and the rapidly declining carbon budget consistent with the Paris Agreement underscore the urgent need for decisive global climate action.

Countries are mandated to submit updated Nationally Determined Contributions (NDCs) in 2025, originally back in February of this year. At the time of writing this report – October 2025 – 62 countries have submitted their updated NDCs, also known as NDCs 3.0, reiterating their commitment to reducing GHG emissions. In the lead-up to COP30 in Belém, the Brazilian presidency has called on countries to participate in *a global mutirão*, or 'collective effort', reinforcing multilateralism and building momentum for more inclusive climate governance. In a significant parallel, the International Court of Justice has delivered a historical decision indicating that the 1.5 °C temperature target is a key interpretation of the goals set out in the Paris Agreement.

In this third edition of the ELEVATE Annual Net-Zero Report, we evaluate the efforts of countries in working toward net-zero targets consistent with the climate goals of the Paris Agreement. The report also explores topics relevant to climate policy in 2025, including the growing focus on trade barriers, the implications of market-based instruments, and the role of justice.

The report begins with an assessment of the progress and shortcomings of current NDCs and net-zero targets. More specifically, **Chapter 2** shows how countries' targets are aligned with the Paris Agreement, particularly those of major emitters, which include the EU, the U.S., China, India and Brazil, as well as Japan and South Africa. We also discuss what the Paris Agreement's targets could imply for the NDCs 2035 targets when taking equity into account.

Building on this, **Chapter 3** considers how shifting geopolitics are shaping current policies and international cooperation. What strategies can sustain progress on climate in an increasingly fragmented world? To answer this, we discuss the effects of energy protectionism, trade retaliation, green industrial policies, and international technological cooperation.

Chapter 4 turns to the market-based and non-market-based policy mechanisms that countries employ to meet their climate goals. Here, we consider the impact of the European Carbon Border Adjustment Mechanism (CBAM), both across countries and various sectors. Furthermore, we investigate who is affected most by carbon pricing and which other policy instruments can help to ensure fairness and increase political acceptability.

As countries submit their NDCs 3.0, they are expected to explain why their targets are fair and ambitious in light of national circumstances. **Chapter 5** discusses the integration of normative considerations in national mitigation efforts. Justice underpins climate action; it can strengthen global commitments and increase public support when approached with clarity and transparency. Finally, the report concludes by providing an outlook on the latest research efforts addressing justice-related gaps in climate scenarios.

ELEVATE
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ELEVATE is funded by the European Union's Horizon Europe programme and brings together leading research institutes with the goal of supporting international climate policymaking. The project aims to develop the necessary scientific understanding of the impact of current climate policies. It focuses on identifying opportunities to mitigate greenhouse gas emissions and supports the preparation of Nationally Determined Contributions (NDCs) and national policies aimed at achieving net-zero emissions by mid-century, in line with the Paris Agreement.

Additionally, the project seeks to establish strong interactions between researchers, policymakers, and other stakeholders. It brings together global and national modelling teams to link the overall progress in meeting the Paris Agreement goals with the implementation of climate policies at the national level. This also includes ensuring their alignment with other sustainable development goals.

More information about the ELEVATE project: www.elevate-climate.org

About the project

Grant Agreement ID: 101056873
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Partners

PBL Netherlands Environmental Assessment Agency (Netherlands) – Project coordinator
PIK Potsdam Institute for Climate Impact Research (Germany)
COPPE/COPPETEC Graduate School of Engineering (Brazil)
UFRJ Universidade Federal do Rio de Janeiro (Brazil)
E3M E3-Modelling AE (Greece)
CMCC Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (Italy)
CS/SCS Climate Strategies (UK/Netherlands)
Aarhus University (Denmark)
TERI The Energy and Resources Institute (India)
IIASA International Institute for Applied Systems Analysis (Austria)
NewClimate Institute for Climate Policy and Global Sustainability (Germany)
Wageningen University & Research (Netherlands)
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External partners:

AFREC African Energy Commission (Africa)
Kyoto University (Japan)
UMD University of Maryland (United States)
KAPSARC King Abdullah Petroleum Studies and Research Center (Saudi Arabia)

2. Gap Analysis

Isabela Tagomori, Elena Hooijschuur, Ioannis Dafnomilis, Constance Crassier, Stephanie Solf, Mark Dekker, Michel den Elzen, Detlef van Vuuren, and national modelling teams

On the road to COP30 – to be held in Belém, Brazil, in November 2025 – countries are announcing new Nationally Determined Contributions (NDCs), which are also expected to include targets for 2035. Unfortunately, many countries have seriously delayed the publication of their new NDCs (NDCs 3.0) and 2035 targets. This report presents an updated assessment of the alignment between current policies, NDCs, and long-term net-zero goals, as well as their cumulative impact towards the temperature goals of the Paris Climate Agreement[1]. Furthermore, given the changing global geopolitical landscape, this report investigates how the rollback of climate policies and commitments in the U.S. affects the global emission pathways and the corresponding implementation and ambition gaps. Finally,

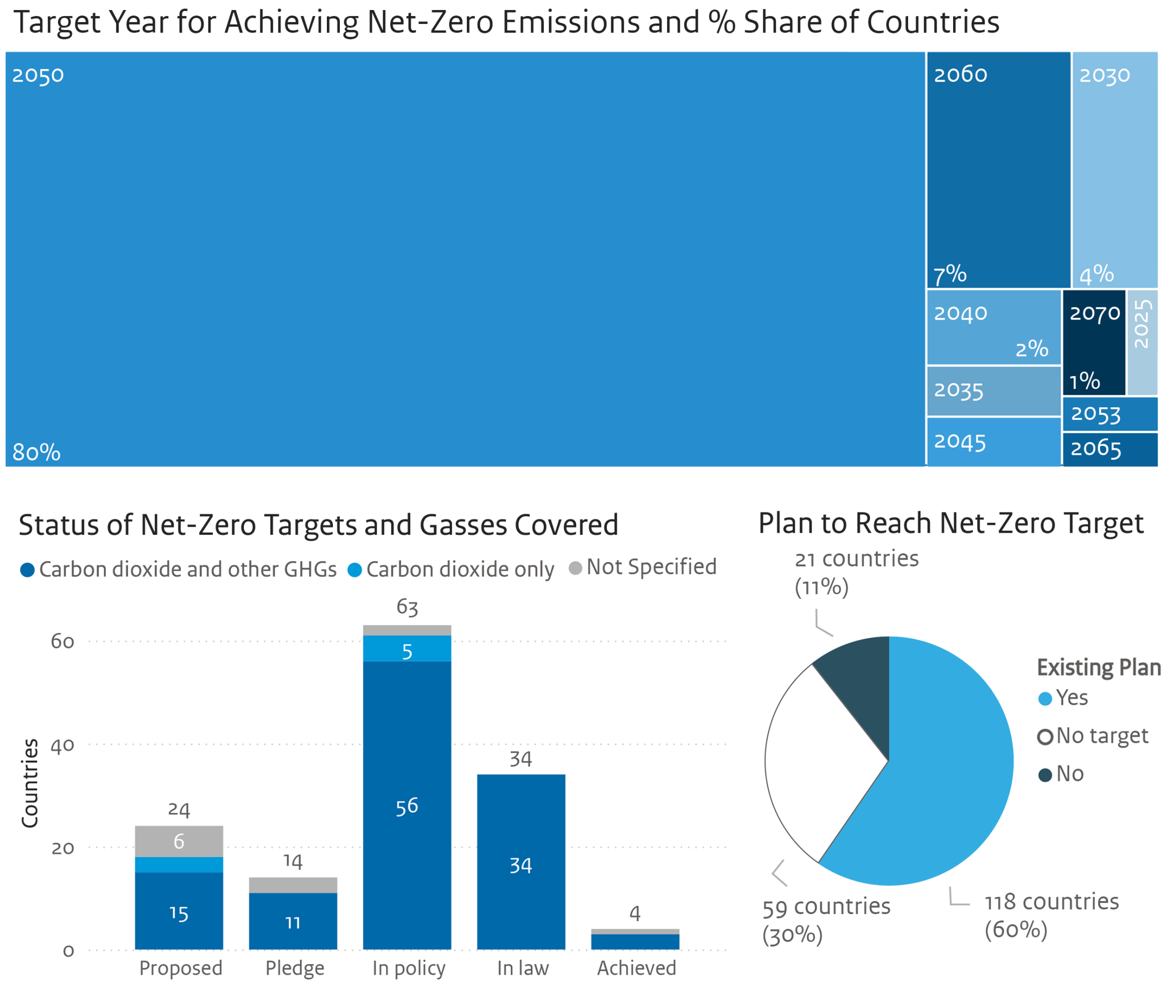

Figure 1: Status of announced net-zero targets, based on data from Net-Zero Tracker (2025). Note: 'Proposed' net-zero targets refers to targets that have been proposed but are still discussed. 'Achieved' net-zero targets are self-declared.

1 Article 2 of the Paris Agreement aims to keep the global mean temperature increase to well below 2 °C (above pre-industrial levels) and pursue efforts to limit the increase to 1.5 °C. In this report, for well below 2 °C we used a limit to greenhouse gas emissions consistent with a 67% probability of staying below 2 °C, equivalent to a likely temperature outcome around 1.7-1.8 °C. For 1.5 °C, we look at scenarios that are expected to be below 1.5 °C by the end of the century with no or limited overshoot.

this report discusses a possible range of 2035 targets for the NDCs 3.0 for six countries: Brazil, China, India, Indonesia, Pakistan, and Vietnam. The new generation of NDCs, or NDCs 3.0, are included as much as possible at the time of writing this assessment, since not all NDCs have been updated yet[2].

2.1. Status of net-zero announcements

This report maps the individual targets and net-zero status for a total of 198 countries[3]. Of this number, 139 have a net-zero emission target that is either proposed, pledged, in policy, in law, or achieved. 118 countries have published a concrete plan on how to reach their target. Most countries asset 2050 as their net-zero target year (80%), and most include both carbon dioxide and other greenhouse gas emissions (GHGs) in their target (86%). In Figure 1, we illustrate the status of announced net-zero emission targets. This updated overview differs substantially from the 2024 ELEVATE Annual Net-Zero Report (van Vuuren et al., 2024), which included a similar figure for that year's analysis. In 2025, the data shows 18 countries have shifted from having targets to having "no target", including the United States, leading to a total of 59 countries[4] with currently no net-zero emission targets. Meanwhile, 8 countries have set new net-zero emission targets, having not had them before. Figure 2 shows which countries have a net-zero goal and which emissions their target covers. For a number of countries (9%), it is not specified which gases are covered by the net-zero target.

2.2. Mind the gap

In this section, we investigate the implementation and ambition gap of current policies and NDCs with the goals of the Paris Agreement, primarily

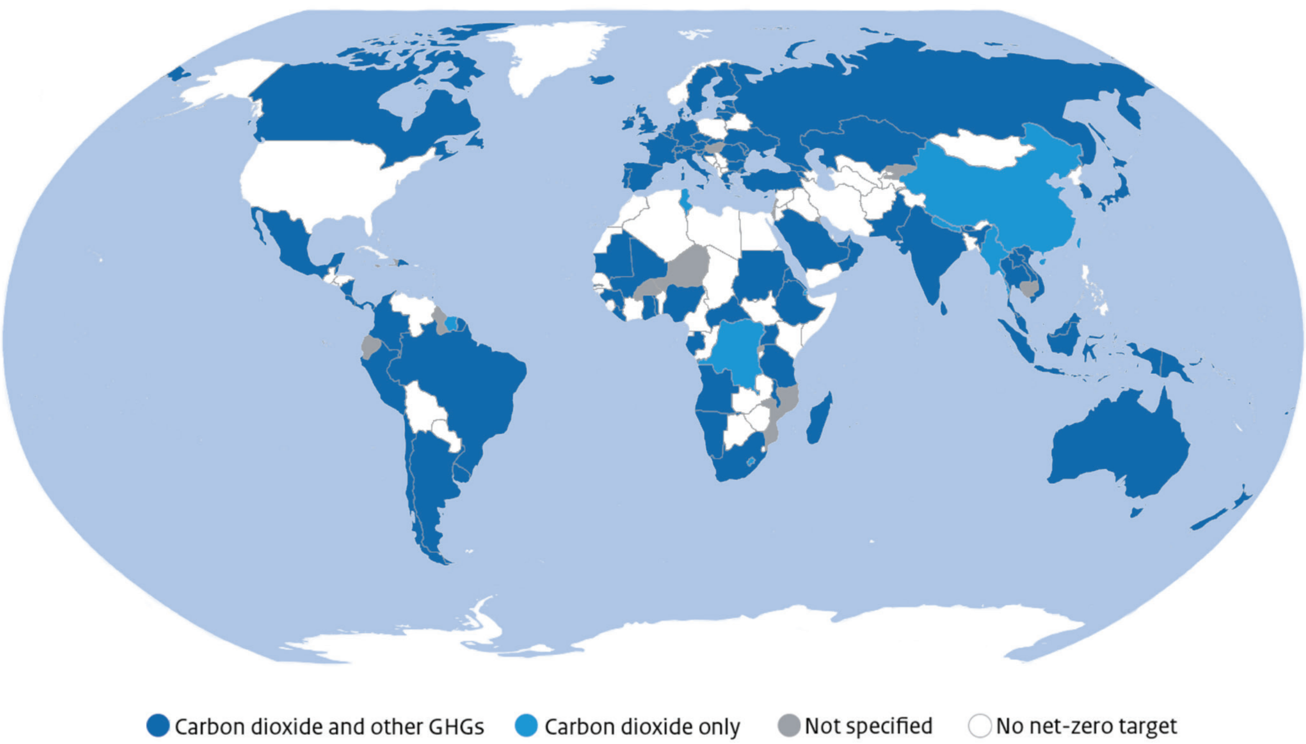

Figure 2: Emissions scope of the net-zero targets per country, based on data from Net-Zero Tracker (2025).

2 From the major emitters assessed in this report, NDCs 3.0 for Brazil and Japan have been published, while China and EU have announced their 2035 targets during UN Climate Summit 2025 (although they have not yet published their NDCs 3.0). Furthermore, for the analysis of expected NDCs 3.0 based on equity principles, Pakistan's NDC 3.0 has been published.

3 Based on data from the Net-Zero Tracker (2025), as of October 28th, 2025.

4 The United States have officially renounced their net-zero emissions goal (One Big Beautiful Bill Act, 2025). For the other countries, we could not find an official announcement, and their removal from the database is possibly related to the lack or withdrawal of policy documents that have previously sustained the pledge.

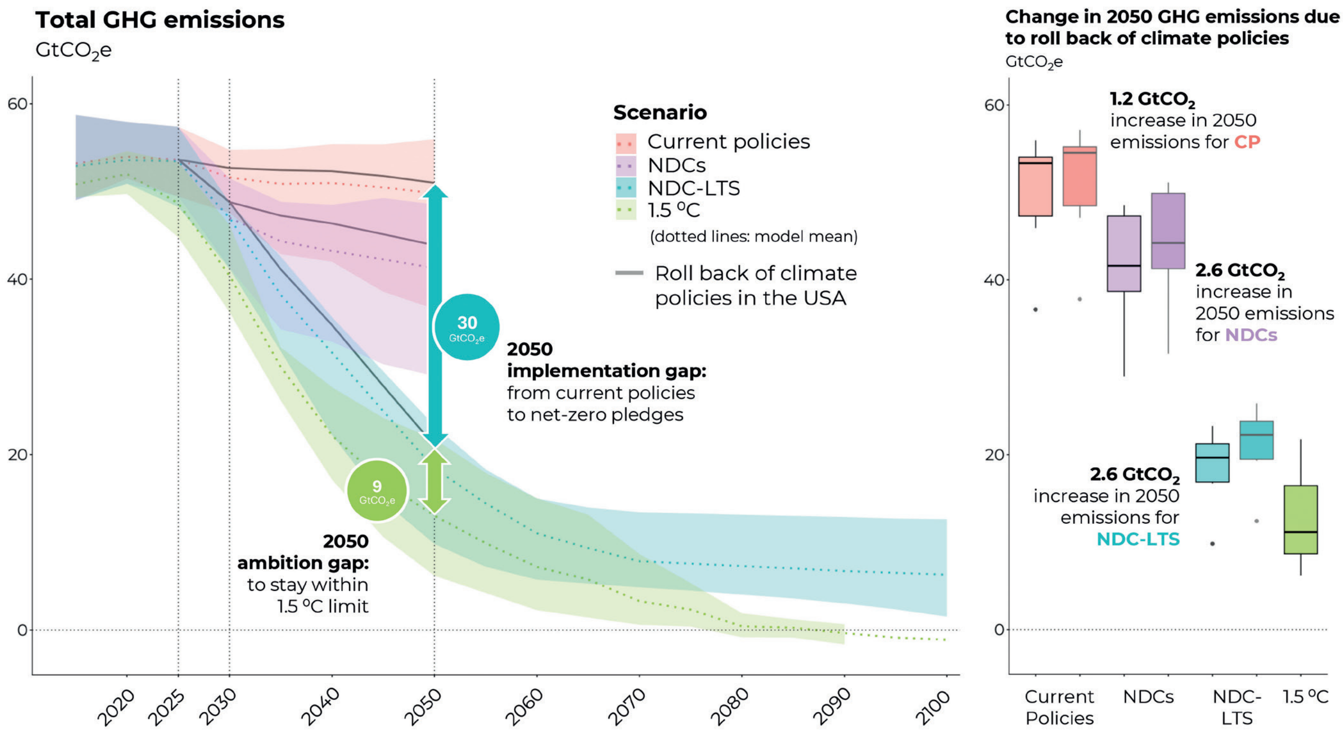

Figure 3: Global GHG emission pathways under various scenarios, the projected implementation and ambition emission gaps in 2050, and the impact of the rollback of climate policies and pledges in the United States. On the left: the impact on the model-mean projected GHG emission pathways, in dark grey. On the right, the impact in the model-ensemble projected 2050 GHG emissions (boxplots grouped per scenario, darker fill and dark grey borders show the projections after the rollback of climate policies and pledges).

focusing on the long-term (net-zero) targets. This is done using the latest information on NDCs, current policies, and integrated assessment modelling (IAM) scenarios consistent with the Paris goals. The analysis also includes the impact of the rollback of climate policies in the U.S. and how it impacts the implementation and ambition emission gaps. We assess such impacts by comparing new projections for global emission pathways to previous projections[5] for three climate policy scenarios: 1) the Current policies (CP) scenario, 2) the NDCs scenario, and 3) the NDCs to Long-Term Strategies (NDC-LTS) scenario. We follow this with an evaluation of these scenarios' consistency with a 1.5 °C trajectory.

Figure 3 below shows the latest and up-to-date progress in implementing the Paris Agreement. The ranges in the figure are derived from multiple models used in the analysis; this therefore reflects a certain degree of uncertainty. As was the case in previous ELEVATE net-zero reports, there is a large gap between the pathways towards the climate goals of the Paris Agreement and the pledges (including NDCs and long-term strategies) and current policy scenarios (referred to in the figure as the ambition and implementation gaps respectively). The overall gap did increase this past year as a result of the rollback of climate policies and climate pledges (including NDCs and long-term strategies) announced by the current administration in the United States. This rollback is expected to increase the ambition gap (i.e. the difference between the overall objective of international climate policy and the sum of all pledges by countries) to 9 gigatonnes of CO2 equivalent in 2050, compared to 6 GtCO2e in our previous report. The implementation gap (i.e. the expected impact of current policies compared to

5 Previous projections for CP, NDCs, and NDC-LTS scenarios as in the 2024 ELEVATE Annual Net-Zero Report (van Vuuren et al., 2024). Given that NDCs 3.0 are still in the process of being published, 2035 targets are not yet included in the scenarios. A full update of all climate policy scenarios will be published in the next edition of the ELEVATE Net-Zero Report (in 2026).

the collective pledges of the long-term strategies and other announced net-zero pledges) reduces to 30 $GtCO_2e$ in 2050 (compared to 32 $GtCO_2e$ in our previous report); this is not due to progress in implementation, but as a result of lower ambition.

Our assessment shows that, because of changes in U.S. policy, GHG emissions in the current policy scenario increase by 1.2 $GtCO_2e$ in 2050 (One Big Beautiful Bill Act, 2025; Dafnomilis et al., 2025). The United States' withdrawal from the Paris Agreement, including their NDC and net-zero pledge, results in an increase of 2.6 $GtCO_2e$ in projected global GHG emission levels[6]. The size of the impact is influenced by the projected autonomous decrease of U.S. emissions. It should be noted that U.S. withdrawal might have spillover effects; as one of the largest emitters, changes in U.S. participation in international climate agreements can influence global dynamics and further widen the emissions gap.

2.3. Tracking major emitters

Even though the U.S. withdrew from the Paris Agreement, it remains important to track their trends, and those of other major emitters. These include but are not limited to the European Union (EU), the United States, China, India, Brazil, Japan, and South Africa, as based on results from PBL's Integrated Model to Assess the Global Environment (IMAGE)[7]. In addition, this section provides an assessment of whether the countries' intermediate targets (their NDCs) are aligned with each country's long-term goals. Recently published NDCs 3.0 for Brazil and Japan, and announced 2035 targets by China and the EU, are also included in our analysis presented in this section[8].

Targets differ in ambition level between the various countries. Here, we do not assess ambition levels and fairness of net-zero targets, but rather if countries are on track to achieve these targets under their respective existing climate policies (for fairness considerations, see section 2.4). The alignment of the NDC with the long-term pledge is defined as the positioning of the NDC target with respect to a linear path of emission reductions from the current year to each country's respective net-zero year (Figure 4)[9]. As such, alignment of an NDC target with a net-zero target is not an indication of whether a country is currently on track to achieve its long-term target, but rather whether the NDC emission target puts the country in question on a linear emissions pathway to meet its net-zero goal.

2.3.1. European Union (EU)

In its revised NDC of October 2023, the EU increased its ambition level for reducing emissions to at least 55% below 1990 levels by 2030 (European Council, 2023). The EU's net-zero target for 2050, covering all greenhouse gases, has been enshrined in law since 2021. It has a relatively clear structure, transparency, and scope, including an analysis to support the target (European Union, 2021). During the UN Climate Summit 2025, the EU announced a possible range for its 2035 target: 66.25-72.5% below 1990 emission levels (European Commission, 2025). The higher end of this range is linked to the EU's proposed target of cutting emissions by 90% below 1990 levels by 2040 (European Commission, 2024).

The EU could be on a linear path to achieve its 2050 net-zero target under current policies. As it stands, the NDC target for 2030 and the proposed target for 2035 are aligned with the EU's net-zero targets, meaning that continuation of the same level of effort after 2030 and 2035 is sufficient to achieve GHG neutrality by 2050. However, it is crucial to note that the EU being on track to achieve its targets considers EU-level policies only. Member States still need to adopt

6 Our projected emissions increase is also supported by other recent analyses, such as the analysis from Carbon Brief (2025), Climate Action Tracker (2025), and Jenkins et al. (2025).
7 More information on the IMAGE model can be found at the IAMC Wiki (2025) and IMAGE's Model Documentation (2025).
8 Cut-off date for inclusion in this report: 15 October 2025.
9 Historical and NDC (unconditional) emission levels are based on Dafnomilis et al 2025 When a net-zero target covers CO_2 emissions only (or when coverage is unclear), GHG emissions at the time of net-zero CO_2 are estimated by applying the most recent ratio between non-CO_2 emission levels and GHG emission levels available in national inventories to the latest NDC's GHG emission level.

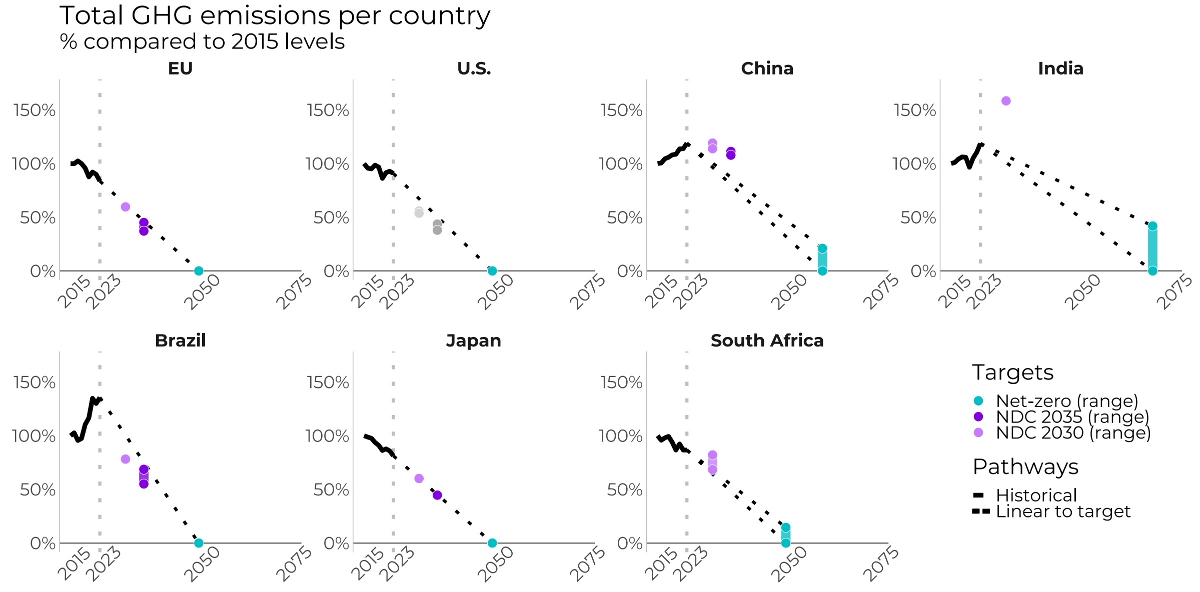

Figure 4: Linear GHG emission pathways between emission levels in 2023 and net-zero targets, and GHG emission levels by 2030 and 2035 corresponding to NDCs. Previous targets of the U.S. are indicated in grey as they are abandoned by the current administration.

and implement more ambitious policies on a national and individual level to be compatible with the EU's collective targets.

2.3.2. United States (U.S.)

The Biden Administration already published the NDC 3.0 back in December 2024, setting a 2035 target of reducing GHG emissions by 61–66% below 2005 levels (Government of the United States of America, 2024). However, one of the first actions by the Trump Administration was to withdraw from the Paris Agreement entirely (Government of the United States of America, 2025), effectively annulling the 2035 climate target. For the same reason, the U.S.' long-term strategy of reaching net-zero GHG emissions by 2050 is no longer considered in effect (Net-zero Tracker, 2025).

For the first time in 30 years, a U.S. Administration was absent from significant climate negotiations, namely those held in Bonn in June 2025 (Berwyn, 2025). Additionally, the U.S.' last climate negotiator was fired in July 2025 (Nilsen, 2025), with the expectation being that the U.S. Administration will be absent from COP30 negotiations in November 2025 as well (Schneider et al, 2025). For the purposes of this report, we therefore consider the U.S.' NDC 3.0 and net-zero emissions target as inactive. In terms of policies, the U.S. also withdrew their key instrument to reduce emissions, the so-called Inflation Reduction Act (IRA). However, given the remaining active policies and existing trends, the U.S. emissions are still expected to decrease over time but at a significant slower rate.

2.3.3. China

China submitted its updated NDC in October 2021, committing to several different targets. China also submitted its official long-term strategy in the same month, proclaiming a commitment to reach net-zero (CO2) by 2060, although the document lacks certain details on gas coverage and clarity on planning (Government of China, 2021). On 24 September 2025, during the UN Climate Summit 2025, President Jinping announced China's target for the NDC 3.0: China aims, by 2035, to reduce economy-wide net greenhouse gas emissions by 7% to 10% from peak levels, with the caveat to strive for even higher reductions. Additionally, the country aims to increase the share of non-fossil fuels in total energy consumption to over 30%, and other targets (CarbonBrief, 2025a).

Both the 2030 and the announced 2035 NDC targets currently do not drive additional emission reductions for China when compared to the country's current policy projections. Emissions in China are projected to peak before 2030 under current policies, with some analyses suggesting they have already peaked in 2024 or will peak in 2025 (Climate Action Tracker, 2025a; CarbonBrief, 2025b). The emission reduction rate post-peak could bring China on a linear pathway towards its net-zero goal. The latter only covers CO_2, not all greenhouse gases.

2.3.4. India

India's NDC 2.0 was submitted in August 2022. It aims to decrease the GHG emissions intensity by 45% below 2005 levels, as well as increase the share of non-fossil energy capacity in the power sector to 50% by 2030 (Government of India, 2022a). India submitted its first LTS at COP27 aiming for net-zero by 2070, but the strategy document does not provide sufficiently transparent information on gas coverage or policy guidance (Climate Action Tracker, 2025b). A recent modelling study shows that India's 2035 target could realistically aim for a 55-66% emissions intensity reduction below 2005 levels and a 60-68% share of non-fossil fuel power capacity (India's World, 2025). India has not yet published its NDC 3.0.

Under current policies, India is expected to increase emissions at a similar rate as it did over the past decade, with no signs of peaking before 2030. Coal is expected to play an important role in its future energy production and supply (Government of India, 2022b). The country is, however, on track to meet its 2030 NDC targets. These targets are currently not in line with India's net-zero target, as the NDC target is clearly above a linear line to net-zero. However, depending on equity considerations this outcome could be different (see section 2.4). Given the relatively low ambition of current policies, alignment with the announced net-zero target would require a more substantial reduction from baseline.

2.3.5. Brazil

Brazil submitted its NDC 3.0 in November 2024, setting a target to reduce GHG emissions between 59–67% below 2005 levels by 2035. This covers all sectors and all gases (Government of Brazil, 2024). Recent analysis suggests that lack of published government data on the expected contribution of the land use sector (LULUCF) to the NDC target, will result in an extraordinarily wide range of projected emissions from all other sectors (excluding LULUCF) that are consistent with the NDC target (Climate Action Tracker, 2025c). Brazil maintains its GHG net-zero emissions target by 2050.

Brazil is currently not on a linear path to meet its declared neutrality targets under existing policies, as emissions in the energy and industry sector are expected to plateau by 2030. With most of the country's emissions coming from the land use sector, achieving the net-zero target will primarily depend on increasing the ambition level and enforcement of land-use related policies. Brazil's NDC 3.0 is aligned with its net-zero target however, as this sets the country on an emission pathway in line with its net-zero target.

2.3.6. Japan

Japan submitted its NDC 3.0 to the UNFCC in February 2025 (Government of Japan, 2025), setting a target of 60% reduction in GHG emissions by 2035 compared to 2013 levels. Additionally, it has a 2040 component that stipulates a 73% reduction from 2013 emission levels. Japan's 2050 net-zero emissions target remains unchanged, covering all GHG emissions and economic sectors, which is also enshrined in domestic law.

Japan is currently on a linear path to its announced GHG neutrality targets under existing climate policies, as emissions have been on a downwards trajectory for the past ten years. If the 2035 target is met and the country continues the same rate of decarbonisation, it can achieve its net-zero target as well, meaning that Japan's NDC 3.0 is aligned with its net-zero target.

2.3.7. South Africa

South Africa submitted its NDC 2.0 in 2021, setting emission levels between 350-420 $MtCO_2e$ in 2030 as a target (Government of South Africa, 2021). A consultation held by the Presidential

Climate Commission (PCC) in May 2025 suggests that South Africa's proposed 2035 emission level target will be 278–330 $MtCO_2e$ (Lindo & Quickfall, 2025), but this has not been confirmed, as South Africa has not yet submitted its NDC 3.0. So far, its government has only stated its intention to commit to a net-zero target by 2050 as part of a visionary statement in its LTS (Government of South Africa, 2020). Under existing policies, South Africa is currently not on a linear path with its net-zero target and would need to increase ambition to do so (Climate Action Tracker, 2025d). Regarding its NDC alignment with its net-zero target, the significant range of emission levels in its 2030 NDC is a major uncertainty factor. The lower range puts the country on an emissions pathway compatible with its net-zero target, but the upper range suggests a plateauing of emissions at their current level.

Table 1: Progress of major emitters towards achieving their net-zero targets and assessment of countries' NDC alignment with net-zero targets

	Net-zero target	On track to achieve net-zero target	NDC target (2035, if applicable, otherwise 2030)	NDC aligned with net-zero target
EU	Net-zero GHG by 2050	EU is on a linear path to achieve its net-zero target	Reduce GHG by 66.25-72.5% below 1990 levels by 2035 (announcement only)	EU's NDC is aligned with its net-zero target
U.S.	No net-zero target in effect	-	No NDC target in effect	-
China	Carbon-neutral before 2060 (CO_2 only)	China is currently not on a linear path to achieve its net-zero target	Reduce GHG by 7-10% from peak levels, striving to do better, and other targets (announcement only)	China's NDC is not on a linear path from its current emissions to its net-zero target
India	Net-zero by 2070 (type of gas not specified)	India is currently not on a linear path to achieve its net-zero target	Reduce GHG intensity by 45% below 2005 levels by 2030 and other targets	India's NDC is not on a linear path from its current emissions to its net-zero target
Brazil	Net-zero GHG by 2050	Brazil is currently not on a linear path to achieve its net-zero target	Reduce GHG by 59-67% below 2005 levels by 2035	Brazil's NDC is aligned with its net-zero target
Japan	Net-zero GHG by 2050	Japan is on a linear path to achieve its net-zero target	Reduce GHG by 60% below 2013 levels by 2035	Japan's NDC is aligned with its net-zero target
South Africa	Net-zero carbon emissions by 2050 (type of gas not specified)	South Africa is currently not on a linear path to achieve its net-zero target	Limit GHG emissions to 350–420 $MtCO_2e$ by 2030	South Africa's NDC could be aligned with its net-zero target considering the lower end of its NDC range

2.4. What would be fair ambitions under the NDCs 3.0?

2.4.1. Analysis based on equity principles for Brazil, China, India, Indonesia, Pakistan, and Vietnam

The 2023 First Global Stocktake showed that, collectively, countries' ambitions and policy implementations are not sufficient to implement the overall climate goals of the Paris Agreement. Countries are asked to submit new NDCs including targets for 2035 in line with the Paris Agreement and, therefore, the common-but-differentiated-responsibility principle, which implies not only increased ambition, but also accounting for equity.

It is possible to indicate what could be emission targets for various countries aligned with the Paris Agreement's 1.5 °C or well below 2 °C degree target by first calculating a global carbon budget and next deriving national targets based on equity principles. Targets derived using such a method could be interpreted as 'fair' realizations of national mitigation goals (including the associated ranges in results). However, it is worth noting that this approach relies on several normative decisions and interpretation of the climate goals of the Paris Agreement as well as the design of the equity principles. Moreover, different perspectives may exist on what is feasible in terms of reduction. In order to partly address these considerations, this section starts with an assessment of the fair target ranges and is complemented by a reflection part on several countries using the expertise of national experts. This includes methodological and contextual (feasibility, political, socio-economic) factors that have not been captured in the quantitative target ranges.

Three fairness principles often mentioned in the literature are equality, capacity and responsibility. For each of these, allocation rules have been proposed. Here, we look at per capita convergence ('PCC'), income-based allocation (ability to pay or 'AP') and allocation account for historical emissions (equal cumulative per capita distribution or 'ECPC'). See the box 'Illustrative calculations'.

The figure below shows the proposed 2035 GHG emission targets (including land use). The markers on each range indicate the default settings as in Dekker et al. (2025). The grey bars indicate cost-optimal results based on latest cross-model scenario submissions under ELEVATE, with mitigation starting in 2025 (using downscaling to country-level data). Historical emissions and indicated targets rely on the same source as in previous chapter, whereas the purple dots here indicate most ambitious emission levels resulting from 2030 and 2035 targets (including conditional elements). The grey solid line indicates historical emissions, and the grey dashed line shows a linear pathway to the countries' net-zero year.

For most of the countries, the 2030 NDC targets fall short of the suggested targets under Paris-aligned effort-sharing principles (the purple NDC dots are above the indicated ranges). For high-income regions/countries like EU and

Illustrative calculations

The three allocation rules have been implemented using the Carbon Budget Explorer (see Dekker et al., 2025). For per capita convergence, we assumed 3 convergence years (2040, 2050 and 2080) of global emissions. For the ECPC rule, we include different starting year for account for historical responsibility: 1850, 1950 and 1990. The blue and green bars in Figure 5 suggest potential targets consistent with the calculations, with mitigation starting in 2021. Additionally, to account for a range of socio-economic developments, we considered the five Shared Socio-economic Pathways (SSPs) projections as uncertainty factors. The calculations are done for two temperature levels: 1.5 °C with no or limited overshoot and well below (>66% probability) 2 °C.

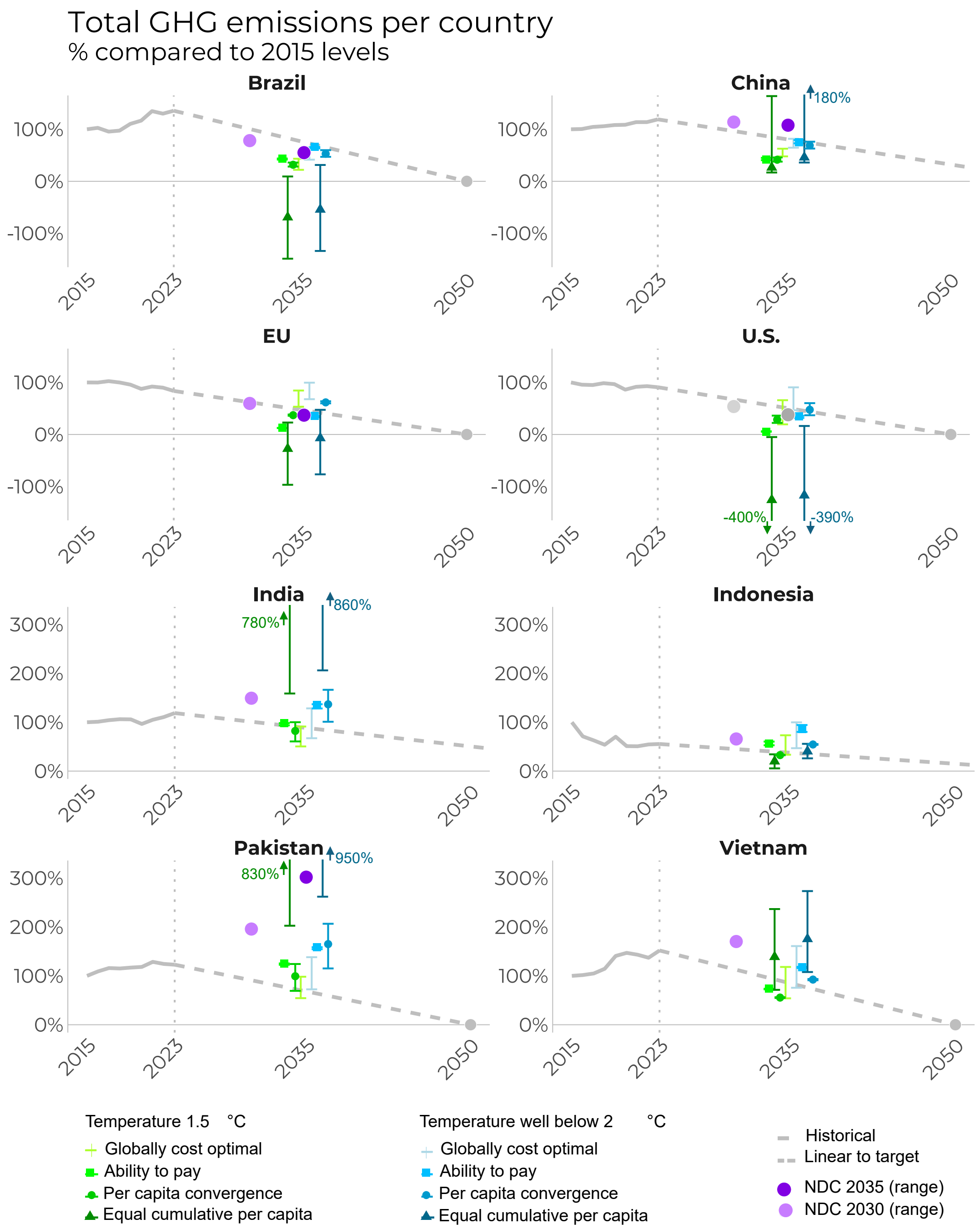

Figure 5: Possible 2035 GHG Emission targets based on equity calculations in line with a 1.5 °C and well below 2 °C global temperature goal

U.S., fairness-based 2035 targets would imply stronger emission reductions in the range of 50%-150% (ref. 2015 emission levels) under both temperature targets, with highest reductions under historical responsibility. EU recently proposed a 2035 target through a "statement of intent" announced during the UN Climate Summit 2025, which falls in most case short of the 1.5 °C equality-based target range. For China and Vietnam, the allocation based on historical responsibility is specifically sensitive to its parameter assumptions so that the 2030 target could be legitimized under this fairness approach. China's recent announcement of its 2035 target only aligns with the upper end of the historical responsibility target range. Under historic responsibility and equality principles (1.5 °C global goal), Indonesia's 2035 reduction target would need to be at least at 50%, compared to 2015. The announced 2035 reduction target for Brazil reasonably aligns with the equality and ability to pay target ranges under the 1.5 °C global goal. India and Pakistan share similar target ranges in terms of fairness-based allocations. Both countries' equality and capability-based targets would imply only minor or no reductions compared to 2015. Pakistan's submitted conditional 2035 NDC target only aligns with the historical responsibility target ranges, for both 1.5 °C and well below 2 °C. Following both countries' relatively low historical emissions, India is allocated much more in the future: at least 50% higher emissions in 2030 compared to 2015 (1.5 °C global target; over 100% under well below 2 °C). While the target ranges may be similar between India and Pakistan, national circumstances and capabilities are completely different and have to be integrated in the analysis.

The results can also be compared to cost-optimal scenarios. If the cost-optimal scenario is higher in terms of emissions that the suggested equity-based targets, a country could consider flexible instruments to achieve its emission reduction targets. If, in contrast, the cost-optimal outcome is lower, there could be a potential of providing emission credits under a possible implementation of Article 6 of the Paris Agreement.

2.4.2. Discussion of national targets

Our analysis is complemented by the reflections from partners in Brazil, China, India, Indonesia, Pakistan, and Vietnam. These reflections concern, on the methodological aspects, results, and implications for climate policy in the respective countries.

Brazil

The Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering of the Federal University of Rio de Janeiro (Coppe/UFRJ) (Roberto Schaeffer)

Brazil's most recent NDC, delivered during COP29, aims at reducing the country's net GHG emissions to between 59% and 67% by 2035, compared to 2005 levels. Through a 'band target', Brazil's NDC defines a range of emission reductions rather than a single rigid value, in order to consider variations in projections of future scenarios given the uncertainties associated with the success in reducing deforestation in the Amazon and Cerrado biomes by 2030-2035. Brazil's new NDC covers all sectors of the economy, and, by design, given the way the BLUES model[10] scenarios were set, it is in line with the target of the country reaching net zero GHG emissions by 2050. The analysis for Brazil from the global modelling results, as shown in Figure 5, indicate that, although the country's original NDC 2030 target falls short of globally cost-optimal and different equity principles for both well below 2 °C and 1.5 °C global goals, a different story emerges for the country's newest NDC 2035. It is far more ambitious than the target ranges under capacity- and equality-based allocations, and slightly more ambitious than the globally cost optimal range, in line with a well below 2 °C global goal (although still less ambitious than the historical responsibility criterion). In the case of the proposed 2035 GHG emission target in line with a 1.5 °C global goal, Brazil's newest NDC 2035 is still more ambitious than the capacity criterion, and within the upper limits of the globally cost-optimal and equality-based target ranges. Ultimately, for the majority of scenarios explored here, Brazil's newest NDC 2035 sits somewhere in between the 1.5 °C and well below 2 °C global goals.

10 The Brazilian Land Use and Energy System (BLUES) model. The link: https://www.iamcdocumentation.eu/index.php/Model_Documentation_-_BLUES

China

Tsinghua University (Wenying Chen, Shu Zhang, Lei Yang) and Zhejiang University (Chenmin He)

China is facing multiple challenges including developing its economy, improving people's livelihoods, protecting the environment, and addressing climate change. Since submitting first NDC, China has been actively trying to fulfil its commitments and accelerating the comprehensive green transformation of its economic and social development. In 2020, China announced the updating and strengthening of its NDCs and its plans to accomplish the world's highest rate of reduction in carbon intensity. Additionally, China has made certain commitments to realize the transition from carbon peak to carbon neutrality in a short period of time, historically speaking, which is China's concerted effort to respond to global climate change based on its own stage of development. To this end, China has completed the '1+N' policy framework of carbon peaking and carbon neutrality, and has set quantitative targets for energy intensity, carbon intensity, and forest coverage in its 14th Five-Year Plan and the Vision 2035 Outline. Quantifiable progress has already been achieved in climate change mitigation, including in energy conservation, non-fossil energy development, and improvements in energy efficiency (Can et al.,2025). The global modelling results as part of ELEVATE show that China's NDC target is in the range of fair metrics but still falls short of the global cost optimum. According to the national analyses, China would be able to achieve its NDC target for 2030, given certain breakthroughs in renewable energy and electric vehicles, but further technological, financial, and policy support is still needed to fully achieve carbon neutrality (Zhang & Chen, 2022).

Furthermore, China's recent rapid development of renewable energy and nuclear power could imply that the country is well under way in its energy transition towards its carbon neutrality, mainly driven by market developments. However, the uncertainty of its economic development and China's tradition to uphold international commitments will intensify the discussion around the ambition of its new NDC. China's CO_2 emissions began to decrease in the first quarter of 2025, which could imply that China has reached its peak of CO_2 emissions in 2024, primarily due to the very fast growth of solar, wind, and nuclear power. Yet, the recent announcement of China's NDC 3.0 signals not much stronger ambition than the NDC 2.0 and only aligns with the historical responsibility principle.

India

Indian Institute of Management Ahmedabad (IIMA) (Saritha Sudharmma Vishwanathan, Jyoti Maheshwari and Amit Garg) and The Energy and Resources Institute (TERI) (Ritu Mathur, Sanchit Agarwal and Saswata Chaudhury)

The global modelling results (absolute emissions) indicate that India's NDC 2030 targets are within selected fairness metrics (equality principle for well below 2 °C, historical responsibility for 1.5 °C), but not within the global cost-optimal or capacity-based range. However, there is a need for rigorous unpacking of the socio-economic narratives assumed and drivers in global models that impact each of the effort-sharing approaches. In fact, the national analyses project that India is on track to achieve its current NDC 2030 targets (Vishwanathan et al., 2024). India is one of the largest democracies working towards achieving its targets pledged under the Paris Agreement and the Glasgow Pact. However, development and energy security remain priorities. Coal will continue to play an essential role in the economy. India's NDCs have been driven by its developmental needs, aligned with the global climate commitments, and based on its national circumstances and capabilities. In the Updated NDCs to UNFCCC in 2015, India increased its emission intensity of GDP from 33-35% to 45% by 2030 relative to 2005 levels. Additionally, it raised its target of installing electric power capacity from non-fossil fuel energy resources from 40% to 50% by 2030. As the majority of India's informal economy and population are highly vulnerable impacts of climate change, adaptation has gained an equal importance along with mitigation. India's climate actions have been largely financed by domestic resources. However, to meet the upcoming challenges of mitigation as well as adaptation, access to international finance will be an essential prerequisite.

An important consideration for India is that the energy transition in low- and middle income countries needs to balance development objectives with decarbonisation actions. From that perspective, India might be fairly ambitious as it seeks to balance a transition to a lower carbon future with affordability, reliability and environmental sustainability. Approaches that evaluate possible burden-sharing methodologies must therefore consider the feasibility of decarbonisation actions while simultaneously making recommendations based on global modelling studies. In that sense, methodologically speaking, the assumption of linear convergence towards a per capita convergence implies constraints on the ability of the right-to-grow for low-and middle-income countries like India. Moreover, global cost optimality alone may not be the most suitable principle for determining carbon budgets and climate actions. This approach relies primarily on technology selection and penetration rates, without sufficient consideration of a country's socio-economic context or equity considerations. Special attention needs to be placed on finance availability and access, including investment opportunities as well as cost of capital. Moreover, there are significant trade-offs between social-, green-, and development-based infrastructure and land requirements for various needs such as forestland, food and energy crop production, urbanization. An improved sensitivity analysis, including such considerations, could generate meaningful and policy-relevant results. Lastly, economic impacts require more attention especially in terms of effects on GDP, employment, and government revenue. Hence, global cost optimisation models need to connect more closely with methodologies that can better evaluate and include the feasible market demands, possible constraints and the trade-offs with national development priorities.

Indonesia

ASEAN Centre for Energy (Ambiyah Abdullah)

Although Indonesia's second Nationally Determined Contribution (NDC 3.0) targets have not yet been announced, ongoing discussions show that the Indonesian government will likely implement a 'no-backsliding policy'. With the already announced net-zero targets, the Indonesian government aims to increase the ambition of the national emission reduction targets by 2035 through the potential inclusion of Hydrofluorocarbons (HFC) emissions and new sectors (maritime and upstream sectors of oil and gas). Moreover, the NDC 3.0 will use 2019 as reference year and consider the updated national mitigation and adaptation policies, as well as the just transition principle. The current results using fairness principles shows that Indonesia's potential emission reduction targets should be increased from the 2030 target and are near or within the global cost-optimal range, and closest to the ability-to-pay principle. However, the choice of potential emission reduction targets will also need to consider potential GDP losses and ensure its alignment with Indonesia's 2045 GDP growth target. Indonesia needs more substantial support from the international community to tackle its key challenges such as closing the financial gap and more robust measurement, reporting and verification (MRV) and NDC progress tracking systems, including carbon pricing, and use of Article 6. The financial gap is projected to increase from the previous estimation, particularly with the announced plan for phasing out coal and the 75GW new renewables capacity addition target by 2050 (ten years earlier than the 2060 net-zero target).

Pakistan

Lahore University of Management Sciences (Talha Manzoor and Muhammad Awais)

Pakistan's recently submitted NDC 3.0 (September 2025) commits to a highly ambitious emissions target, aiming to reduce its projected 2035 emissions of 2,559 $MtCO_2e$ to 1,280 $MtCO_2e$, equivalent to a 50 percent cut, comprising 17 percent unconditional and 33 percent conditional reductions. This target is based on a very high baseline trajectory that assumes rapid GDP growth and industrial expansion. The conditional portion of the reduction remains a major concern, as it relies on substantial international climate finance, technology transfer, and capacity building. The updated NDC estimates a total investment requirement of approximately USD 565.7 billion by 2035, of which the conditional component will depend on external financial support. Despite these ambitious plans, Pakistan's economic growth since 2020 has been constrained by pandemic impacts, political instability, and recurring climate disasters – factors that have limited domestic fiscal space for mitigation investments. The government emphasizes that the scale of its ambition far exceeds domestic capacity, and that external support is critical to realizing the full mitigation potential. While Pakistan's 2035 NDC represents progress over previous submissions and can be considered consistent with a well below 2 °C fairness-based range, it still falls short of the deeper reductions required under a 1.5 °C pathway. Nevertheless, emerging domestic trends such as rising electricity prices and rapid deployment of rooftop solar may accelerate decarbonization beyond official pledges, narrowing the gap between conditional and unconditional outcomes.

Vietnam

International University-HCMC (Tran Thanh Tu, Nguyen Vu and Hoang Phuong)

Among the three effort-sharing rules, the historical responsibility allocation scheme suggests a less stringent reduction target for Vietnam, at least considering targets in its current NDC 2.0. Following the capability and equality-based rules, the 2035 target needs to be more stringent for Vietnam, which corresponds to the country's willingness to achieve more ambitious targets. Looking at global cost-optimality alone might overestimate the ability of Vietnam to bear climate mitigation costs. Therefore, the NDC 3.0 target for Vietnam should consider possible socio-economic impacts such as direct GDP loss as well as increasing carbon and fuel prices. By 2030, a reduction of 34.5% emissions from current policy level might lead to at least 4.1% GDP loss and 41.3 USD 2005/tCO_2 carbon price, while the implications of a 43.8% reduction in 2035 are 6.4% GDP loss and 52.3 USD 2005/tCO_2e carbon price. Thus, for more ambitious targets, Vietnam needs to receive knowledge and experience sharing from international communities, as well as a clear roadmap to identify appropriate investment directions and financial support.

KEY FINDINGS

- Current policies and NDCs are not on track to meeting the goals of the Paris Agreement. By the middle of the century, this report estimates that the rollback of climate policies in the U.S. would result in an emissions gap between current policies and trajectories consistent with the 1.5 °C target of around 39 GtCO_2. The gap consists of a lack of ambition and a lack of implementation, and increased compared to our last year's report (38 GtCO_2e).
- Out of the seven largest emitters analysed in this report, four (Brazil, EU, Japan and South Africa) have an NDC that is on a linear path towards their net-zero targets – meaning that if they manage to achieve their NDC target and maintain the same emission reduction rate afterwards, they could achieve their long-term target.
- However, there are clearly different views on what constitutes fair and feasible reduction targets. It is possible to derive a range of 2035 targets based on equity principles and the global climate targets. In most cases, the 2030-2035 NDC targets fall short of what would be consistent with the Paris Agreement, according to effort-sharing principles.

3. Climate policy in times of increasing geopolitical tensions

Lara Aleluia Reis

3.1. Geopolitical context

In recent years, geopolitical tensions have increased around the world. One consequence of this has been the introduction of various trade-related measures. While **security of supply** has long been a priority for most countries, **free trade** was traditionally viewed as a key mechanism to help ensure that security.

The COVID-19 crisis in 2020 and 2021 exposed vulnerabilities in global supply chains, prompting many countries to reconsider their dependence on imports for critical resources. This shift was further accelerated by Russia's full-scale invasion of Ukraine in 2022, which marked a turning point in global geopolitics. Western countries responded with sanctions, trade, and energy policy shifts, exposing the fragility of fossil fuel supply chains and raising energy security concerns.

This instability has been compounded by the rise of economic nationalism, maybe best illustrated by the recent trends in the United States. The re-election of Donald Trump as president led to a move away from international trade cooperation toward the unilateral and often unpredictable use of tariffs. These changes pose a threat to the willingness of countries to work together on major global issues like climate change.

There are many relationships between climate policy and trade and cooperation. Tariffs can make it more difficult to import new, green technologies but also form a motivation to be less dependent on imports of fossil fuels. In fact, several climate policies also have direct trade and industrial policy elements. Examples include the Carbon Border Adjustment Mechanism (CBAM) proposed by the EU to protect its industry and the U.S. launching under the Biden Administration the $370 billion Inflation Reduction Act to support clean energy and domestic manufacturing. Also, the EU's Green Deal Industrial Plan and the Net-Zero Industry Act are meant not only to reduce emissions but also to boost local investment and competitiveness.

These initiatives combine climate goals with economic and strategic motivations. The momentum behind this green technology competition was consequently weakened by geopolitical tensions. History shows that sanctions and a push for national self-sufficiency often go hand in hand, with self-reliance viewed as a way to secure energy supplies. But such protectionist approaches can make it harder for countries to cooperate on shared challenges like climate change and sustainable development.

Recent geopolitical shifts also challenge the assumptions of stable cooperation and cost-optimal deployment in climate scenarios, highlighting the need to study baselines that move toward energy autarchy (i.e. energy self-sufficient) and strategic, costlier decisions that may undermine climate goals. Building on current geopolitical tensions, it is interesting to analyse how energy independence policies, where countries seek to secure their energy supply from foreign risks, may impact climate policy. This is presented here using an ensemble of coupled climate-energy-economy models. The analysis is just one possible example of how trade policies may influence climate policy. The goal, therefore, is more to show the relevance of including geopolitical considerations in climate policy than to present exact numbers.

The analysis looks at 3 scenarios. One counterfactual 'baseline' scenario without additional tariffs. In the **National Tariff scenario**, all regions impose import tariffs equal to their domestic carbon price, which reflects both their climate ambition and economic capacity. This leads to lower tariffs in less wealthy regions and stronger disincentives for carbon-intensive imports in high-income regions. In the **Retaliation scenario**, regions with below-average carbon prices apply higher tariffs matching the global average, simulating a stronger response from lower-income regions.

3.2. Energy system transformations, climate outcomes and broader implications

The results on the implication of energy import tariffs are summarised in Figure 6, that shows the primary energy mix when introducing tariffs. We observe substantial oil reductions in non-exporting regions (medium value of −0.36 megawatt-hours per year per person (range:−0.98; −0.08) for the Global North and −0.41 MWh/yr/cap (Range:−0.60; −0.23) for the Global South in the Retaliation scenario). Cutting fossil fuel use remains key for climate mitigation and brings immediate co-benefits, for energy security and air pollution (Achakulwisut et al. 2023).

Tariffs on fossil fuel imports thus lead to modest decarbonisation under energy security–driven policies. Meeting the Paris Agreement requires nearly 400 gigatonnes of CO_2 ($GtCO_2$) (range:−484; −279) in cumulative reductions over the 2020–2050 period compared to the NDC scenario. Tariffs would reduce emissions by 14 $GtCO_2$ (range:−14; −8) in the National and 33 $GtCO_2$ (range:−57; −31) in the Retaliation scenario—at most 8% of what is needed, in line with previous findings (Jewell et al. 2016).

The construction of the required electricity system depends on critical materials. Figure 7 compares each region's cumulative demand in the NDC no-tariff scenario to its known reserves. Only the Pacific OECD, due to Australia, is self-sufficient for the five main critical materials; all other regions remain partially or heavily dependent on imports. In the National tariff scenario, demand increases in most regions, worsening existing shortages, though not enough to deplete reserves in self-sufficient regions. The Retaliation scenario shows slightly higher demand, but the overall pattern is similar. These results highlight the continued importance of international trade in critical materials and the limits of achieving full energy independence.

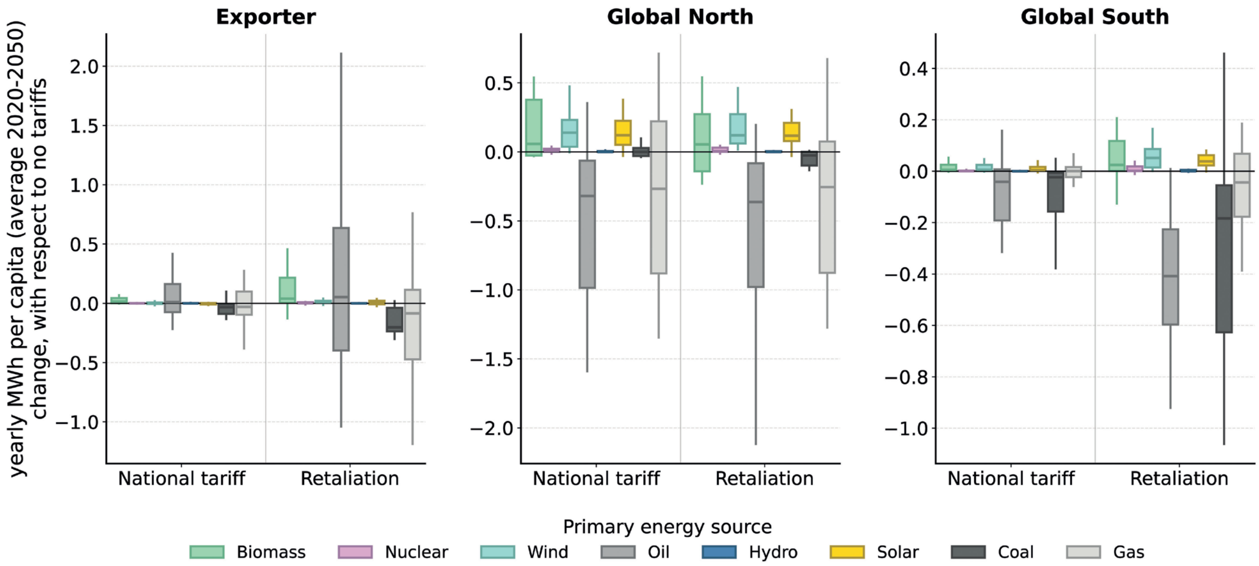

Figure 6: Implication of the tariffs explored. Per capita primary energy change by source with the introduction of tariffs compared to a baseline without tariffs. The boxplots summarize data where each point is average yearly primary energy use over the period 2020-2050, across two dimensions: region and model.

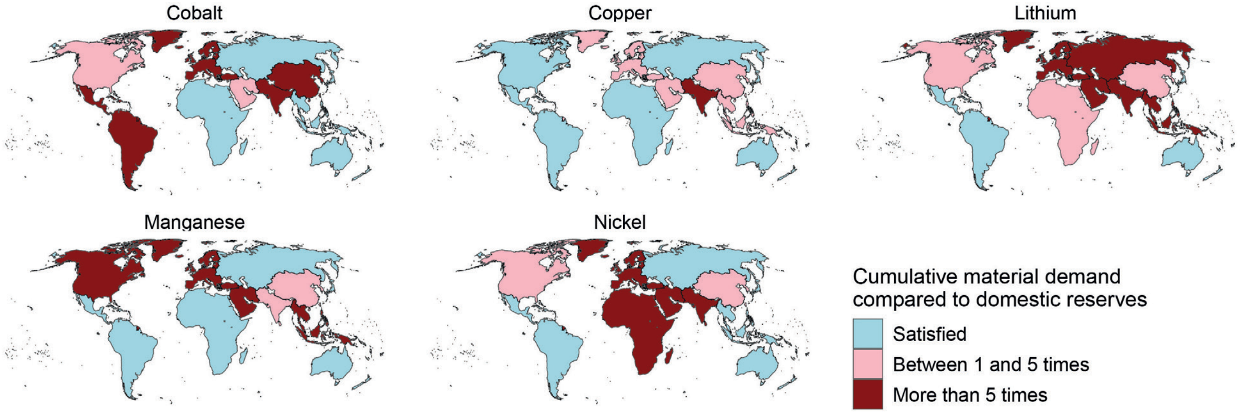

Figure 7: Projected materials demand without tariff.

3.3. Conclusion

The example presented here is based on six integrated assessment models exploring the effects of energy protectionism, trade retaliation, green industrial policies, and reduced international technological cooperation (Aleluia Reis et al., in review).

Our findings show that strategies aimed at energy independence and trade retaliation entail high economic costs and offer limited climate benefits. Their main impact is a reduction in fossil fuel use and greater deployment of renewables, especially in non-exporting countries applying high tariffs. Fossil fuel exporters are particularly vulnerable to import tariffs. Though they may see some gains in non-energy exports, their macroeconomic outcomes are highly uncertain.

True energy autarky is unrealistic due to the global concentration of critical materials needed for clean technologies. This continued interdependence suggests that some level of international cooperation remains necessary.

Redirecting tariff revenues into green infrastructure, such as renewables, electric vehicles, and carbon capture, can offer a more constructive path. While not a replacement for global coordination, such industrial policies can help maintain progress on decarbonisation in a fragmented world.

KEY FINDINGS

- Strategies for energy independence and trade retaliation have high economic costs and limited climate benefits, mainly reducing fossil fuel use and increasing renewables in non-exporting countries with high tariffs. Fossil fuel exporters are especially vulnerable to such tariffs, and their overall economic outcomes remain uncertain.
- True energy autarky is unrealistic given the global concentration of critical materials, making some international cooperation essential. Using tariff revenues for green infrastructure can support decarbonisation, even in a fragmented world.

4. Market mechanisms

Dimitris Fragkiadakis, Ioannis Charalampidis, Zoi Vrontisi, Eleni-Christina Gkampoura, Paola Rocchi, Edoardo Campo Lobato, Valentina Bosetti, Alice Di Bella, Régis Rathmann, Roberto Schaeffer, Jan Steckel, Leonard Missbach

4.1. Market-Based Mechanisms: Role and Key Challenges

To achieve the emission reductions mandated by the Paris Agreement, countries employ a combination of market-based and non-market-based policy instruments. Market-based approaches—such as carbon taxes, emissions trading systems (ETS), carbon crediting, and, recently, carbon border adjustments—aim to internalise the external costs of greenhouse gas emissions and sending price signals that steer firms and consumers toward low-emission choices (Goulder & Stavins, 2012). On the other hand, non-market-based strategies include regulations (e.g., fuel efficiency standards), subsidies (e.g., feed-in tariffs, EV incentives), and public investments in infrastructure or research and development (R&D). Since 2010, the adoption of explicit carbon pricing has expanded to approximately 24% of global emissions (up from 14%), with 75 carbon taxes and ETSs in place, mostly in high-income economies (though increasing in middle-income ones) (IMF, OECD, UNCTAD, World Bank, & WTO, 2024). Research indicates that pricing schemes can reduce emissions by approximately 10% in the years following their implementation, while offering greater flexibility and cost-effectiveness compared to most other regulations (Döbbeling et al., 2024; Stechemesser et al., 2024).

Despite these successes, market-based instruments face persistent challenges that can limit both their environmental effectiveness and political feasibility. Recurring obstacles include design flaws and weak institutional capacity. For instance, ETSs often suffer from issues such as low market participation, irregular trading, speculative behaviour, misallocation of permits, and allowance oversupply, which all weaken price signals and credibility (Chevallier, 2012; Ellerman & Buchner, 2007). Additionally, inefficiently low prices and poor integration with broader climate policies further undermine their effectiveness (Rafaty et al., 2021; Döbbeling-Hildebrandt et al., 2024). Many low- and middle-income countries face limited administrative capacity, hampering monitoring, enforcement, and public trust (Berahab et al., 2024). Uncertainty also poses significant risks: carbon price volatility deters long-term investment, revenue fluctuations complicate compensation or green spending (Goulder & Stavins, 2012; World Bank, 2018), and the threat of stranded fossil assets triggers resistance from incumbent sectors.

An additional significant challenge is the lack of international coordination in carbon pricing. Uneven policy stringency leads to competitiveness concerns and carbon leakage, just as emissions-intensive production shifts to jurisdictions with weaker regulations (Goulder & Stavins, 2012). These dynamics, known as the Pollution Haven Effect and Hypothesis (Levinson & Taylor, 2008; Taylor, 2005), undermine the integrity of climate policies. Without a coordinated framework, such misalignments can result in policy spillovers, trade tensions, and increased administrative burdens (IMF, OECD, UNCTAD, World Bank, & WTO, 2024). One initiative to address this is the EU's Carbon Border Adjustment Mechanism (CBAM). By aligning carbon costs between domestic and foreign producers, CBAM illustrates how market-based tools can mitigate international policy misalignments, which, as explored in Chapter 3, are increasingly shaped by growing geopolitical tensions.

In addition to these challenges, carbon pricing also raises distributional concerns that influence fairness and political acceptance. In high-income countries, carbon pricing is often regressive, disproportionately affecting lower-income households. Conversely, in low- and middle-income countries, the pricing can be progressive, as wealthier individuals tend to consume more energy (Ohlendorf et al., 2022; Dorband et al., 2019). This variation in household costs is influenced not only by income but also by factors such as cooking fuel, geographic location, and vehicle ownership (Missbach & Steckel, 2024), further complicating the political economy of carbon pricing. Revenue use is critical in addressing these disparities; although lump-sum household transfers are theoretically efficient, most jurisdictions use a mix of transfers, industry compensation, and budget funding (Maestre-Andrés et al., 2019; Klenert et al., 2018). Public support is typically highest for green infrastructure investments (Mohammadzadeh-Valencia et al., 2024), but targeting the most affected households remains challenging, even in high-capacity countries.

As discussed in Chapter 3, there is a chance that these challenges intensify in a fragmented geopolitical context. Rising protectionism, energy security concerns, and retaliatory trade measures are already reshaping the conditions under which climate policies operate. Chapter 4 is focused particularly on the role of market mechanisms. Therefore, the following sections focus on two central challenges for market-based instruments: managing competitiveness and carbon leakage through the EU CBAM regulation (Section 4.2) and addressing fairness and political acceptance via distributional impacts across households (Section 4.3).

4.2. Coordination challenges and carbon leakage: the EU CBAM

The EU's CBAM is the first major instrument directly addressing competitiveness risks and carbon leakage as the result of uneven global carbon pricing. By aligning carbon costs between domestic and foreign producers, it aims to cut EU emissions 55% by 2030 and reach climate neutrality by 2050 (European Union, 2023). With no global consensus, similar mechanisms may emerge in other major economies. This first section examines CBAM from three critical perspectives: i) its macroeconomic and trade implications; ii) the potential shifts in dynamics when trading partners strengthen their domestic climate policies; and iii) the specific implications for Brazil's key commodity exports, which could face challenges under this framework.

Will the CBAM initiate changes in international trade patterns? Evidence from a general equilibrium assessment

Researchers anticipate CBAM to influence and even reshape international trade patterns by affecting the relative competitiveness of energy-intensive sectors. To explore these dynamics, this section presents a model-based assessment using the GEM-E3 computable general equilibrium (CGE) model, which provides three scenarios reflecting increasing global levels of CBAM adoption. The GEM-E3 model is designed to capture macroeconomic and trade impacts, particularly focusing on how CBAM impacts export changes and bilateral trade shifts in CBAM-regulated sectors across key economies.

GEM-E3-FIT is a large-scale, multi-sectoral hybrid computable general equilibrium model. It is designed to assess the economic impacts of external shocks in the context of policy changes, particularly in relation to climate and energy policies. The model captures complex interactions between the economy, energy systems, and the environment, offering detailed insights into sectoral output, prices, trade, and emissions. In total, GEM-E3-FIT encompasses 47 global regions and covers 50 economic activities, with a strong emphasis on the energy system. It includes detailed modules for power generation, transport, and buildings, while also incorporating advanced features like endogenous technical progress, labour skill formation, and carbon market mechanisms.

For this research, we quantified three alternative scenarios, reflecting different adoption rates of CBAM measures by major economies. The first scenario (EUCBAM) assesses the impacts of the EU CBAM alone. The second scenario, called CBAMG1, evaluates the impact of carbon border taxes by a group of countries (the G1 group, which includes the US, UK, Japan, and Australia) for the same products covered by the EU CBAM. The third scenario, CBAMG2, extends this assumption by including China, India, and Canada, which all impose carbon taxes on imports. The products subject to all assessed CBAM schemes are specified in the EU CBAM Regulation (EU) 2023/956.

Macroeconomic impacts of CBAM are primarily influenced by several factors: sectoral greenhouse gas (GHG) intensity, carbon price differentials between trading partners, bilateral trade patterns, the economic significance of sectors affected by CBAM, and downstream cost effects. Across all scenarios, the global GDP impacts are minimal, ranging from -0.02% to -0.11%, with effects becoming more pronounced over time. Similarly, global trade is only slightly affected, with overall exports declining by 0.1% in the EUCBAM scenario, 0.14% in CBAMG1, and 0.15% in CBAMG2. These results indicate that, while CBAM introduces some trade and economic shifts, its broader macroeconomic consequences remain limited.

The impact of CBAM on total exports varies across countries (Figure 8). Japan and South Korea experience slight cumulative increases, whereas most other nations experience declines as more countries adopt CBAMs. The EU27 faces the most significant export losses – up to -0.66%) – primarily due to higher intermediate input costs that reduce competitiveness, especially in non-CBAM manufacturing sectors. However, EU exports of CBAM-regulated products improve as global CBAM adoption increases. India and Türkiye are particularly affected, due to high emissions intensity and strong trade ties with the EU, respectively. Countries like China, Brazil, and India manage to offset some losses through increased exports of non-CBAM goods, such as carbon capture and storage equipment. In contrast, Canada experiences export declines when key partners like the US adopt CBAM, especially in non-ferrous metals. The UK initially benefits but later faces losses, while fossil fuel exporters such as Indonesia, Australia, and the US are indirectly impacted. Energy sector exports decline globally across all scenarios, except in the UK, where they see a slight increase.

In the EUCBAM scenario, we categorised countries into two groups based on their export performance. The first group are those nations like China, India, Indonesia, Brazil, and Türkiye that see declines in CBAM-related exports. The second group contains countries that experience export gains such as the US, Canada, Japan, Korea, and Australia. India and Türkiye are the most negatively affected by CBAM, while countries like the UK, US, and Australia benefit most by capturing lost EU market share. As more countries adopt the regulation – as we explore in CBAMG1 and CBAMG2 – trade patterns shift even further. Canada, for example, faces export losses when the US implements CBAM, whereas Japan and South Korea gain market share in India and China. Overall, CBAM adoption results in increased production costs in high-emission countries, which affects competitiveness and alters bilateral trade flows, particularly in CBAM-regulated sectors.

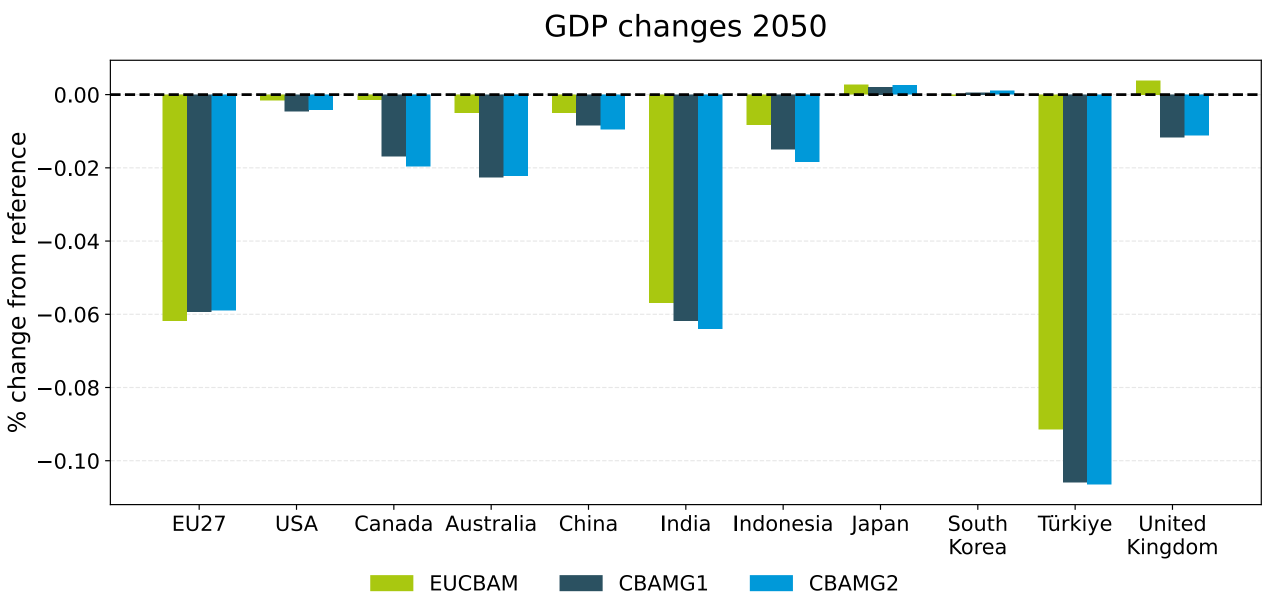

Figure 8: Changes in GDP in the CBAM scenario (% change from reference)

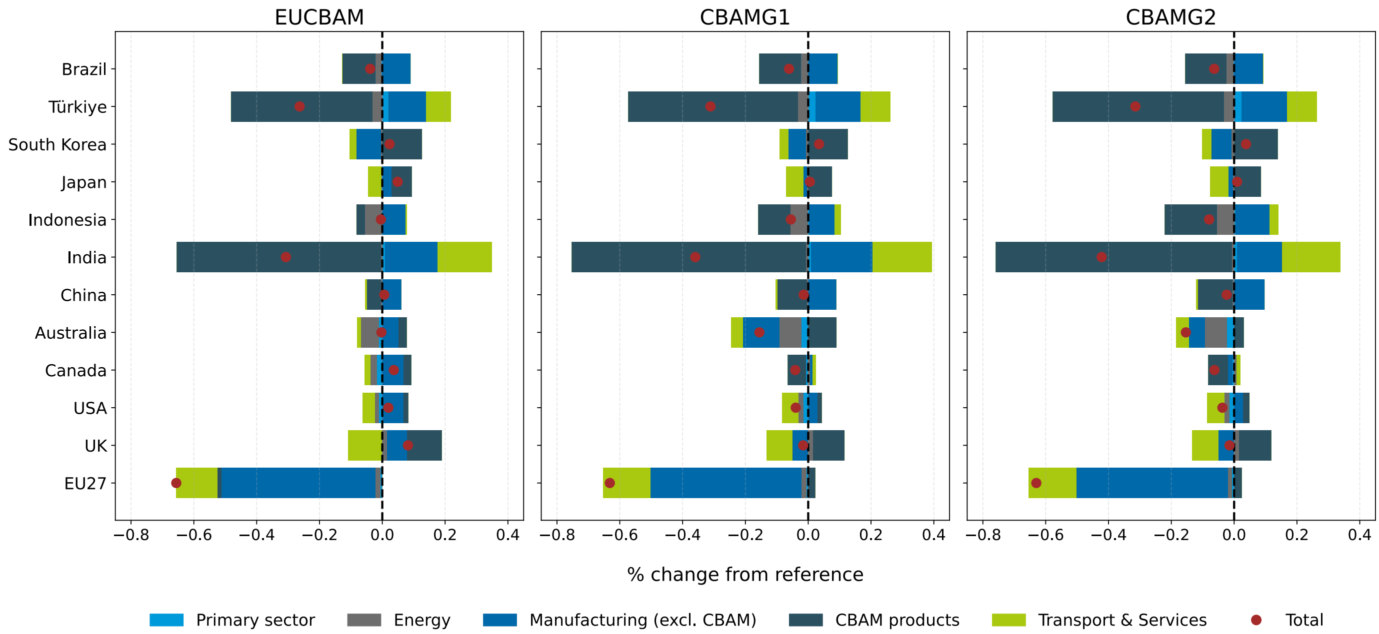

Figure 9: Decomposition of cumulative export changes in the CBAM scenario

In conclusion, while global GDP impacts of CBAM are modest, the mechanism introduces a new competitiveness dimension based on carbon intensity. This affects countries like China and India more severely due to their reliance on fossil fuels. Although CBAM helps reduce carbon leakage, it can also increase production costs in non-protected sectors, leading to broader competitiveness losses, especially in the EU. Effective implementation of CBAM requires coordinated domestic and international policies, transitional support for vulnerable industries, transparent emissions accounting, and strategic reinvestment of CBAM revenues to ensure a just and equitable transition.

Expanding carbon pricing boundaries and the EU CBAM: insights into China and India

In this section, we assess the macroeconomic, trade, and environmental effects of the EU CBAM, and examine how these dynamics shift when trading partners strengthen their climate policies. Our analysis focuses on scenarios where China and India introduce carbon pricing in those sectors covered by CBAM, with partial or full exemptions for their exports. This approach allows us to evaluate implications for trade, competitiveness, and emissions.

Our analysis uses the FIDELIO global, multi-sector, neo-Keynesian general equilibrium model (Rocchi et al., 2025), incorporating emissions intensities from FIGARO and FIGARO-E3 (Cazcarro et al., 2024). CBAM is modelled as an ad valorem tariff based on import CO_2 intensity and imports of the ETS price, phased in as free allowances are withdrawn (European Union, 2023). The scenarios analysed include a baseline with the revised ETS, implementation of CBAM in the EU, and variants where China and India adopt carbon pricing.

Results from the baseline CBAM scenario align with previous findings in the scholarship: GDP impacts are modest – well below 0.5% in all regions – and global emissions reductions are limited. However, CBAM does prompt sectoral and trade shifts, which leads to a reduction in EU imports of energy-intensive goods from carbon-intensive producers such as China, India, and non-OECD economies. This shift simultaneously boosts intra-EU trade and encourages sourcing from other, cleaner OECD suppliers.

If China or India were to introduce domestic carbon pricing, the effects of CBAM would shift significantly. Partial exemptions would reduce the re-shoring of energy-intensive production, thereby limiting both the intra-EU trade boost and the associated rise in EU emissions. Imports from China and India would decline less sharply. The effects are asymmetric: India's decarbonisation leaves China's exports largely unchanged, while China's decarbonisation erodes India's potential gains. These differences reflect variations in market size, sectoral composition, and EU trade integration, illustrating how CBAM can foster strategic linkages between third-country climate policies.

This prompts the question: how are these results reflected in policy? The implications of CBAM extend beyond the quantitative results. While trade shifts favour cleaner exporters, they may burden developing and export-dependent economies, heighten World Trade Organisation (WTO) dispute risks (Espa et al., 2022), and pose administrative challenges for emissions verification (Vidovic et al., 2023). Addressing these issues will require technical assistance, transitional exemptions, and strategic diplomacy. Moreover, CBAM's indirect effects may be more influential than its direct environmental impact. It has enabled the EU to phase out free allowances in energy-intensive sectors and has spurred climate policy developments in countries such as Brazil, Indonesia, and Türkiye (World Bank, 2024). Strategic interdependence emerges when policy timing differs, as evidenced by India's advantage eroding if China decarbonises first. Ultimately, CBAM is one element in a much broader climate policy mix. Its effectiveness depends on stable design, international cooperation, and consistent regulation. While it could become a useful strategic tool to reduce asymmetries in environmental regulation, retaliatory measures could undermine its ability to support low-carbon investments.

Specific implications of the CBAM impacts on the competitiveness of the main Brazilian commodities on the international market

One country that relies heavily on its exports of primary goods is Brazil. It uses its exports to control monetary policy and obtain foreign currency on the international market. Brazil's main export products include crude oil, soybeans, and iron ore, which are transported by sea to, predominantly, China, the EU, and the US.

As part of its efforts to revise the ETS, the EU has introduced the CBAM, which mandates importers of certain energy-intensive commodities to purchase emission reduction certificates. Initially, CBAM will apply to iron ore within the iron and steel sector among the commodities exported by Brazil. However, it could potentially extend to other products such as crude oil and soybeans, given the energy-intensive nature of oil extraction and the link between soybean production and deforestation. Even if CBAM was intended to offset the competitive effects of a more stringent ETS on European industries, its compatibility with WTO rules has been questioned by several countries (Rocchi et al., 2024). This is a prevalent concern mainly among exporting countries, including emerging and developing economies like Brazil.

Here, we discuss some of the impacts of CBAM on Brazil's emissions and GDP. We also examine the extent to which the profitability of Brazil's commodity sectors is affected by policies aimed at mitigating the impacts of carbon pricing, specifically through efforts to reduce the energy intensity of commodity transportation routes to EU countries. To carry out this analysis, we used the PAEG computable general equilibrium (CGE) model (Gurgel, 2013; Nazareth et al., 2017) in conjunction with the Global Trade Analysis Project (GTAP) 11 database. The policy scenario in question combines a comprehensive EU ETS with the EU CBAM. Given Brazil's export profile, we assumed a broader CBAM coverage than currently in force, thereby expanding the existing list of products—iron and steel, aluminium, fertilizers, and cement—to also include crude oil and soybeans.

Introducing CBAM modestly impacts CO_2 emissions across EU countries, Brazil (BR) and all economies (TOT), particularly in energy-intensive industries. This policy results in a slight increase in CO_2 emissions, which can be attributed to an increased production activity which, in turn, raises emissions from energy-intensive commodities.
Our analysis of CBAM policy impacts on

GDP revealed negligible impacts for Brazil, EU countries, and other global economies. However, given the significant role of the primary commodity sectors in shaping Brazil's GDP, the negative impacts on GDP were around three times greater than those seen in China by Rocchi et al (2024).

The main indirect impacts of CBAM affect the profitability of Brazil's exports, defined as the index of export prices, exchange rates, and production costs for key commodities like crude oil, soybeans and iron ore. Petrobras, Brazil's national oil company, anticipates a strong increase in its operating margin in 2024, which would allow it to deal with the small drop in profitability compared to that of the CBAM scenario. Furthermore, the EU market is not even Brazil's primary export destination. Soybean profitability would potentially be highly affected; however, export prices are generally established in long-term contracts and primarily target the Chinese market.

In conclusion, while current design of the EU CBAM policy may be relevant for the profitability of Brazil's primary commodity exports, particularly in agriculture, the anticipated loss of profitability in exports to EU member states is a legitimate concern. Despite these challenges, the overall impact on Brazil's GDP remains relatively small.

4.3. Distributional Effects

Carbon pricing results in higher costs for energy, goods, and services in the short term, which can disproportionately affect low-income households. These regressive effects raise concerns about fairness and political acceptability. In many high-income countries, carbon pricing tends to be regressive, whereas in low- and middle-income countries, it can be progressive (Ohlendorf et al. 2021; Dorband et al., 2019) .

Indeed, carbon pricing affects households differently, which has significant implications for the political economy of climate policy. When the benefits of climate policy are widely dispersed across society, but their costs are concentrated on specific groups, it becomes challenging to implement such policies effectively.

Many complementary policy instruments are conceivable to minimise the heterogeneous effects of carbon pricing on different actors. For example, interventions such as tax reductions, green spending, and undifferentiated transfers can help recipients cope with increasing consumption costs. Theoretically, efficient climate policy instruments can be designed without adverse distributional effects by precisely targeting transfers, thereby giving higher compensation to more affected households. This approach minimises the impact on groups bearing higher costs without distorting the carbon price signal.

Designing carbon pricing with minimal distributional effects thus requires insight into household characteristics that drive differences in the additional costs. In a recent paper, Missbach and Steckel (2024) contribute to this debate by combining detailed household-level expenditure data and multi-regional input-output data for more than 1.5 million households to estimate the household-level additional costs of carbon pricing. Then, they use supervised machine learning to identify the most important factors explaining differences in the additional costs among households.

Their analysis yields important insights. For example, if cooking fuel choice is a strong predictor of whether a household is more heavily affected by carbon pricing or not, transfers differentiated by fuel type can effectively offset distributional effects. By also considering factors beyond income, the study addresses variations in policy impacts within income groups that are often overlooked in the research. The findings show that, in many countries, predicting variation in additional costs is difficult – leaving space for targeting errors. This risks leaving households that are otherwise heavily affected despite compensation. Predictive factor also varies by country. Missbach and Steckel therefore identify six clusters of countries with similar determinants. In some countries, cooking fuel choice and household expenditures are an important predictor for the additional costs of carbon pricing, while in others, electricity access or car ownership are more relevant.

Figure 10 illustrates the contribution of various factors why households are affected using the example of Mexico. In this country, car ownership contributes 35% of the variation in relative additional expenditures from carbon pricing. Households that own cars are more likely to be affected than those without. Effective compensation strategies in Mexico would therefore include transfers that are differentiated based on car ownership, region – particularly for households in the northern provinces, which are most affected – and possibly total household expenditures.

Overall, addressing distributional effects due to carbon pricing is inherently country-specific. Designing carbon pricing policies that are perceived as fair and politically viable (Maestre-Andrés et al. 2019) therefore need to reflect such country-specific circumstances. Using revenues from carbon pricing to finance lump sum transfers, while visible and currently popular in climate policy design, will likely be insufficient, as total household expenditures are often a poor predictor for variation in additional costs.

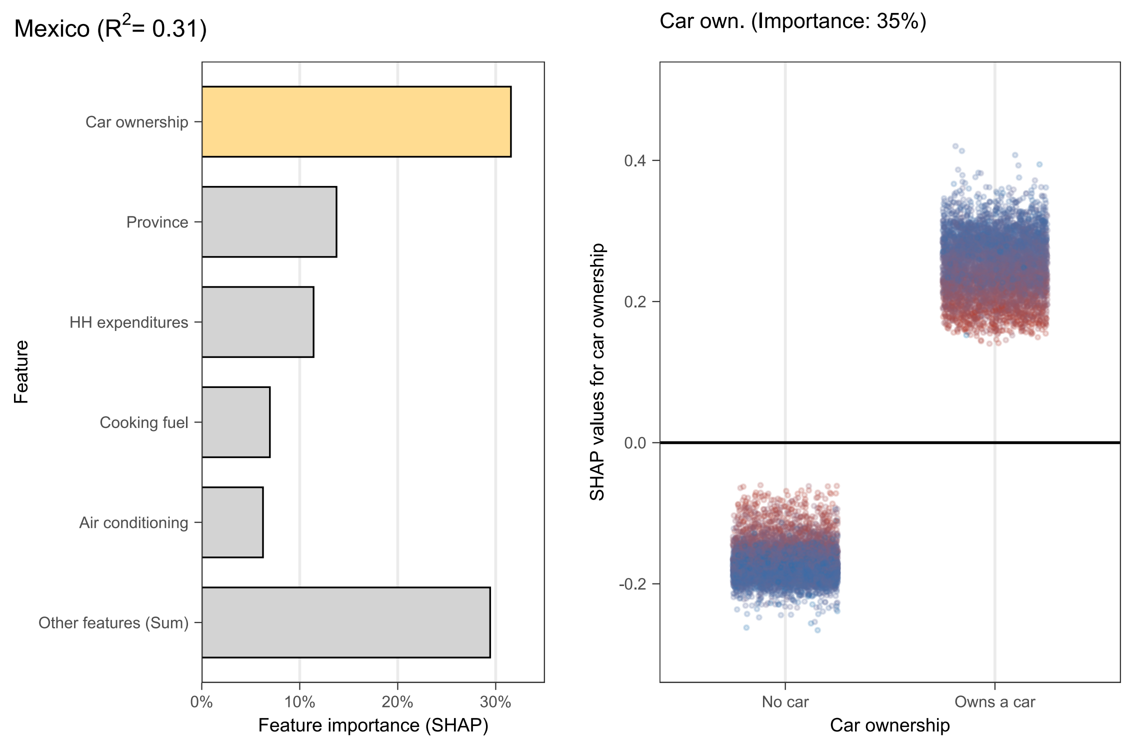

Figure 10: Factors predicting variation in relative additional costs of carbon pricing in Mexico: The left panel displays the most important factors (features) for predicting the relative additional costs of carbon pricing. Feature importance is calculated based on SHAP values. SHAP values indicate the contribution of each feature to each individual prediction. In this figure and for each individual in our sample, it indicates the carbon intensity of consumption (in kgCO2/USD) that can be attributed to owning or not owning a car. Factors are ordered from most important to least important with several least important factors aggregated as "Other features (Sum)". The right panel displays SHAP values for car ownership and individual households from the test sample. They are represented as blue and red using a transparency of 10%. Overlapping values lead to higher transparency. (There are a lot of observations for Mexico, which is why it is difficult to see variation in transparency).

In practice, many countries allocate carbon pricing revenues for multiple purposes. Some of the revenue is recycled back to households through differentiated and undifferentiated transfers, while other portions compensate industries or finance the general budget (Klenert et al. 2018). Various compensation options can increase public acceptance of carbon pricing, with green infrastructure investments generating the largest boost in public support (Mohammadzadeh-Valencia et al. 2024). Nevertheless, it remains critical whether governments can compensate specific segments of the population with such high precision. Even governments with substantial institutional capacity struggle to implement effective compensation measures. Building on existing transfer mechanisms, which are well-established in many low- and middle-income countries, may not necessarily be sufficient to target those households most affected by carbon pricing. For example, existing cash transfer programmes in Latin America and the Caribbean reach only a fraction of those households that would be most heavily affected by carbon pricing, and many of these households, who do not have access to cash transfers, are comparably poorer (Missbach et al. 2024).

Carbon pricing remains a cornerstone of international climate policy and has delivered sizeable emissions reductions over decades. However, its long-term political viability depends on addressing the resulting distributional impacts. Designing compensation measures that are tailored to country-specific circumstances, thereby potentially complementing existing social transfer instruments, can enable a cost-efficient, fair, and politically viable transition to net zero.

KEY FINDINGS

- The EU CBAM has only modest global GDP and trade effects, but it alters competitiveness by favouring cleaner producers and penalising carbon-intensive exporters. Its impacts vary across countries and sectors.
- The effect of domestic carbon pricing on the EU CBAM varies significantly across major exporting countries, thereby highlighting its role in shaping strategic interdependence.
- While the EU CBAM effect on Brazil's GDP is small, it could significantly affect the profitability of key commodity exports – especially soybeans – underscoring the importance of sector-specific trade and price dynamics.
- Who is affected by carbon pricing depends largely on country-specific circumstances. Effective compensation measures will need to be differentiated by different dimensions, including factors beyond income.

5. Outlook on Justice Considerations

Elina Brutschin, Setu Pelz, Shonali Pachauri, Mark Dekker, Elmar Kriegler, Keywan Riahi

As countries move towards achieving net-zero emissions, integrating justice into climate policy is increasingly being acknowledged as vital. This chapter explores how justice should be embedded in mitigation scenarios and their translation to inform national planning.

5.1. Integrating Justice in Models

We define justice as multidimensional, spanning distributive, procedural, recognitional, corrective, transitional, intergenerational, and, where relevant, interspecies considerations, drawing on recent work conceptualising Earth System Justice and its use in climate science (Gupta et al. 2023; Zimm et al., 2024). Justice has multiple entry points in scenario generation: narratives, model structure and parametrisation, policy representations and in the interpretation of outputs. Recent literature calls for greater incorporation of justice considerations in integrated assessment models (IAMs) (Clift & Kuzemko, 2024; Hickel & Slamersak, 2022; Kanitkar et al., 2024; Millward-Hopkins et al., 2024). Efforts to respond to these concerns are gaining momentum, spanning new narratives, modelling tools, and the research culture itself (Pachauri et al., in review).

There have been considerable advances in integrating justice over the past five years, such as increased considerations of regional heterogeneity (Bauer et al., 2020; Bertram et al., 2024), as well as sustainable development focused pathways (Soergel et al., 2021, 2024). However, several significant justice dimensions remain underrepresented, in both the literature and in practice, including gender and other recognitional aspects of justice. Advancing on this requires a concerted effort, including broadening geographic, disciplinary, researcher and stakeholder diversity (Pachauri et al., in review).

Looking ahead, core avenues to better embed justice in global mitigation scenarios could include evolving process and practice beyond ad hoc consultation toward more substantive participation across narrative design, quantification, and interpretation, while diversifying the researcher base by including teams from under-represented regions (Pachauri et al., in review). Greater transparency around normative choices, objective functions, discounting, equity principles, carbon-price architectures, and resource limits could be paired with context-sensitive interpretation using justice-relevant indicators. Bridging scales by robust downscaling of global results to countries, systematic curation of national and sectoral pathways, and integration of bottom-up national scenarios with top-down IAMs can make international equity assumptions more explicit. Substantively, broadening the scenario space to examine faster economic and social convergence and to explore pathways foregrounding guaranteed access to essential energy services and Decent Living Standards, alongside health co-benefits and beyond-growth perspectives, can align mitigation with development priorities (Kikstra et al., 2025; Min et al., 2024; Soergel et al., 2024). Complementary emphasis on demand-side and social transformations (Grubler et al., 2018; Rao et al., 2019; Rao & Wilson, 2022; van den Berg et al., 2019) and on precautionary governance of land, nature, and CDR with realistic scale-up assumptions (Dooley et al., 2024) could be coupled with exploratory layers that operationalise equity, for example through differentiated carbon budgets and effort-sharing metrics.

5.2. Justice considerations in national mitigation efforts

Integrating justice into models must go hand in hand with improving how scenario outcomes are interpreted in policy processes, such as during the development of NDCs under the Paris Agreement. We discuss recent advances in this context here.

A principles-first approach to defining fairness in national mitigation ambition

Under the latest NDC cycle, also known as NDC 3.0, countries are expected to explain why their targets are fair and ambitious within their national context. Recent work by Pelz et al. (2025) demonstrates how this normative expectation of fairness can be operationalised, following a structured sequence that begins with a decision on the set of principles being applied and how they are interpreted in context, bringing value judgements into view ex ante rather than implicitly embedding them in modelling choices. The next step is to specify the quantity being allocated in line with these considerations. Here, some countries may work with a share of some remaining carbon budget at some point in time, others with a share of some global emissions pathway. In all cases, the intended temperature outcome and the relevant period of assessment should be stated, including a range of other considerations, such as how land use emissions (and sinks) and non-CO_2 emissions are handled. With the quantity fixed, an allocation approach and the indicators that implement it can be defined. A range of principles and allocation approaches are available here, with strong arguments for coherence between these and international environmental law (Rajamani et al., 2021). Whichever way these are selected, the emphasis remains on documenting what is used and why, and on showing consistency with the principles deemed contextually relevant in the first step. The final step is to present what the set of allocations imply for the country and for others, and then to compare that with domestic ambitions. Any gaps should be plainly described and presented together with a plan to address it through increased domestic action and international cooperation. The result is a clear and transparent communication of a desired normative position that invites reasoned multilateral deliberation while simultaneously providing sufficient sovereign flexibility in defining 'fair' national contributions.

Consequences of leaving principles implicit

When such a sequence is not followed, fairness principles may remain implicit, making it more difficult to interpret and to compare across countries and over time. Recent work emphasises that normative framing is the largest source of variation in national allowances (Dekker et al., 2025). Its influence extends beyond allocation approaches to choices about temperature outcomes, scope for land use and non-CO_2 gases, and the availability or timing of carbon dioxide removal. Without a clear sequence of assessment starting with the principles and norms considered relevant, intent must be inferred from modelling artefacts rather than assessed on stated merits, which weakens confidence in both the analysis and the policy justification.

Vagueness in the assessment sequence allows modelling choices to stand in for value judgements, producing wide ranges that rest on unstated assumptions. The result is an apparent alignment between a domestic pathway and a fair share assessment that does not hold once the required balance between implied domestic action and feasible international cooperation is taken into account. Ambiguity also complicates legal scrutiny and public oversight by obscuring which elements are empirical uncertainties and which are normative choices. Moreover, as datasets and scenarios are updated, numbers can drift due to collective inaction and for technical reasons unrelated to any change in principles, moving the goalposts and eroding progression. The remedy is to make choices explicit before calculation, to document credible alternatives, and to recognise that each choice matters and can be reasonably justified (Dekker et al., 2025; Pelz et al., 2025). Doing so separates purpose from method and makes the resulting numbers traceable. It invites scrutiny while preserving the flexibility countries need to reflect national circumstances. Most importantly, it creates a stable evidentiary record that clearly links fairness claims to principles and their quantifications, enabling consistent tracking of ambition and a coherent bridge to any subsequent treatment of overshoot.

Overshoot and persistent responsibilities

Crucially, such normative considerations do not drift into irrelevance simply because remaining budgets are exhausted or when global temperatures temporarily overshoot a chosen limit. The expectation under NDC 3.0 is that countries explain how their contributions are fair and ambitious; that same expectation carries into the overshoot period. The same principles-first sequence can be extended to show, in a traceable way, how reliance on removals and international cooperation will be managed and on what ethical basis (Pelz et al., 2025). The aim is to maintain a transparent link between declared principles, empirical inputs, and the numbers that follow from them, even when the focus shifts from allocating emissions to allocating drawdown responsibilities. A practical way to do this is to keep a cumulative balance that compares, for each country, cumulative emissions from the agreed start year through to net zero under a proposed pathway with its principle-based allocation over the same interval (Pelz, et al., 2025). Exceeding the allocation indicates (future) accrual of overshoot responsibility and points to the need to accelerate domestic mitigation and support additional mitigation or removals beyond the domestic pathway now. Such a balance is allocation-agnostic and can be nationally determined following the sequence described above. This underlines that fairness considerations remain operational as countries move from limiting emissions to delivering and supporting drawdown.

5.3. Recent modelling community efforts

We note several ongoing initiatives tackling justice-related gaps in the current scenario space. The NAVIGATE[1] project developed three archetypal narratives: Economy-Driven Innovation, a high-growth, supply-side transformation steered by markets, technology, and price signals within clear public regulation; Resilient Communities, which prioritises sufficiency and well-being through equitable sharing, strong demand-side shifts, and locally-led post-growth strategies (especially in high-income countries); and Managing the Global Commons, which relies on robust national and international institutions to coordinate efficient provisioning across supply and demand, with services-oriented economies and moderate growth in the North alongside faster growth in the South (Soergel et al., 2024). The project also developed and quantified new GDP trajectories with stronger interregional economic convergence (Min et al., 2024).

A recent study advances how scenarios are evaluated against multiple planetary boundaries (van Vuuren et al., 2025). It shows that implementing the Paris Agreement, shifting to healthier diets, and improving food as well as water- and nutrient-use efficiency can substantially reduce boundary transgressions, while acknowledging that, even then, several boundaries (including climate change, biogeochemical flows, and biodiversity) remain breached by 2050 due to inertia.

Within the ELEVATE project[2], the modelling community broadened researcher participation in assessing how justice should be considered within models (Low et al., 2025) and introduced a scenario protocol to quantify these elements directly (Pelz et al., forthcoming). A key advance is the assessment of three justice dimensions in a multi-model comparison: (i) intra- and intergenerational justice via carbon-debt accounting and regionally differentiated mitigation efforts; (ii) stricter constraints on biomass use and geological CO_2 storage to reflect interspecies and precautionary concerns; and (iii) the ex-ante inclusion of Decent Living Standards thresholds within models rather than as ex-post indicators.

The NEWPATHWAYS project[3] will extend this agenda by using development-focused socio-economic projections (DSPs) to generate a new suite of global mitigation pathways, thereby broadening the diversity of socio-economic development trajectories considered. These pathways are intended to inform the 2028 Global Stocktake as well as assessments such as the UNEP Emissions Gap Report and the IPCC Seventh Assessment Report.

1 https://www.navigate-h2020.eu/
2 https://www.elevate-climate.org/
3 https://newpathways.eu/eoi-development-focused-socio-economic-projections/

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Annex 1: List of Net-Zero Targets per Country

Based on Net Zero Tracker (2025)

Country Name	Net-Zero Target	Status of Net-Zero Target	Coverage of Net-Zero Target	Has Plan
Afghanistan	No target	No target	No target	No
Albania	No target	No target	No target	No
Algeria	No target	No target	No target	No
Andorra	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Angola	No target	No target	No target	No
Antigua and Barbuda	Net zero	In policy	CO_2 and other GHGs	No
Argentina	Net zero	In policy	CO_2 and other GHGs	Yes
Armenia	Climate neutral	In law	CO_2 and other GHGs	Yes
Australia	Net zero	In law	CO_2 and other GHGs	Yes
Austria	Climate neutral	In law	CO_2 and other GHGs	Yes
Azerbaijan	No target	No target	No target	No
Bahrain	Net zero	Pledge	Not Specified	No
Bangladesh	Net zero	In policy	CO_2 and other GHGs	Yes
Barbados	Net zero	In policy	CO_2 and other GHGs	Yes
Belarus	No target	No target	No target	No
Belgium	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Belize	Net zero	In policy	CO_2 and other GHGs	Yes
Benin	No target	No target	No target	No
Bermuda	Net zero	In policy	Not Specified	Yes
Bhutan	Carbon negative	Achieved	CO_2 and other GHGs	Yes
Bolivia	No target	No target	No target	No
Bosnia and Herzegovina	No target	No target	No target	No
Botswana	No target	No target	No target	No
Brazil	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Brunei Darussalam	Net zero	In policy	CO_2 and other GHGs	Yes
Bulgaria	Climate neutral	Pledge	CCO_2 and other GHGs	Yes
Burkina Faso	Net zero	In policy	CO_2 and other GHGs	Yes
Burundi	No target	No target	No target	No
Cambodia	Net zero	In policy	CO_2 and other GHGs	Yes
Cameroon	No target	No target	No target	No
Canada	Net zero	In law	CO_2 and other GHGs	Yes
Cape Verde	Net zero	In policy	CO_2 and other GHGs	Yes
Cayman Islands	Net zero	In policy	CO_2 and other GHGs	Yes
Central African Republic	Net zero	Proposed	CO_2 and other GHGs	Yes
Chad	No target	No target	No target	No
Chile	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
China	Carbon neutral(ity)	In policy	CO_2 only	Yes
Colombia	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Comoros	Net zero	In policy	CO_2 and other GHGs	Yes

Country Name	Net-Zero Target	Status of Net-Zero Target	Coverage of Net-Zero Target	Has Plan
Congo	No target	No target	No target	No
Costa Rica	Net zero	In policy	CO_2 and other GHGs	Yes
Côte d'Ivoire	No target	No target	No target	No
Croatia	Climate neutral	In policy	CO_2 and other GHGs	Yes
Cuba	No target	No target	No target	No
Cyprus	Climate neutral	In policy	CO_2 and other GHGs	Yes
Czech Republic	Climate neutral	In law	CO_2 and other GHGs	No
Dem. Rep. Congo	No target	No target	No target	No
Denmark	Climate neutral	In law	CO_2 and other GHGs	Yes
Djibouti	Net zero	Proposed	CO_2 and other GHGs	Yes
Dominica	Carbon neutral(ity)	In policy	CO_2 only	Yes
Dominican Republic	Net zero	In policy	CO_2 and other GHGs	yes
Ecuador	No target	No target	No target	No
Egypt	No target	No target	No target	No
El Salvador	No target	No target	No target	No
Equatorial Guinea	No target	No target	No target	No
Eritrea	No target	No target	No target	No
Estonia	Net zero	In policy	CO_2 and other GHGs	Yes
Eswatini	No target	No target	No target	No
Ethiopia	Net zero	In policy	CO_2 and other GHGs	Yes
European Union	Climate neutral	In law	CO_2 and other GHGs	Yes
Fiji	Net zero	In law	CO_2 and other GHGs	Yes
Finland	Climate neutral	In law	CO_2 and other GHGs	Yes
France	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Gabon	Carbon neutral(ity)	Achieved	CO_2 and other GHGs	No
Georgia	No target	No target	No target	No
Germany	Net negative	In law	CO_2 and other GHGs	Yes
Ghana	Net zero	Pledge	CO_2 and other GHGs	Yes
Greece	Climate neutral	In law	CO_2 and other GHGs	No
Grenada	No target	No target	No target	No
Guatemala	No target	No target	No target	No
Guinea	Net zero	Proposed	CO_2 and other GHGs	Yes
Guinea-Bissau	No target	No target	No target	No
Guyana	Net zero	Achieved	Not Specified	No
Haiti	Net zero	Proposed	Not Specified	No
Honduras	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Hungary	Net zero	In law	Not Specified	Yes
Iceland	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
India	Net zero	In law	CO_2 and other GHGs	Yes
Indonesia	Net zero	Pledge	CO_2 and other GHGs	Yes
Iran, Islamic Republic of	No target	No target	No target	No
Iraq	No target	No target	No target	No
Ireland	Climate neutral	In law	CO_2 and other GHGs	Yes

Country Name	Net-Zero Target	Status of Net-Zero Target	Coverage of Net-Zero Target	Has Plan
Israel	Net zero	Proposed	Not Specified	No
Italy	Climate neutral	In policy	CO_2 and other GHGs	Yes
Jamaica	Net zero	Pledge	Not Specified	No
Japan	Net zero	In policy	CO_2 and other GHGs	Yes
Jordan	No target	No target	No target	No
Kazakhstan	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Kenya	No target	No target	No target	No
Kiribati	Net zero	Proposed	CO_2 only	No
Kuwait	Carbon neutral(ity)	Pledge	Not Specified	No
Kyrgyzstan	Carbon neutral(ity)	Proposed	Not Specified	No
Laos	Net zero	In policy	CO_2 and other GHGs	Yes
Latvia	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Lebanon	Net zero	In policy	Not Specified	Yes
Lesotho	Net zero	Pledge	CO_2 and other GHGs	No
Liberia	Net zero	In policy	CO_2 and other GHGs	No
Libya	No target	No target	No target	No
Liechtenstein	Net zero	In law	CO_2 and other GHGs	Yes
Lithuania	Climate neutral	In policy	CO_2 and other GHGs	Yes
Luxembourg	Net zero	In law	CO_2 and other GHGs	Yes
Macedonia, the former Yugoslav Republic of	No target	No target	No target	No
Madagascar	Net zero	Proposed	CO_2 and other GHGs	Yes
Malawi	Net zero	Pledge	CO_2 and other GHGs	Yes
Malaysia	Net zero	In policy	CO_2 and other GHGs	Yes
Maldives	No target	No target	No target	No
Mali	Net zero	Proposed	CO_2 and other GHGs	Yes
Malta	Climate neutral	In policy	CO_2 and other GHGs	Yes
Marshall Islands	Net zero	In policy	CO_2 and other GHGs	Yes
Mauritania	Carbon neutral(ity)	Proposed	CO_2 and other GHGs	yes
Mauritius	Carbon neutral(ity)	Proposed	Not Specified	No
Mexico	Net zero	In policy	CO_2 and other GHGs	Yes
Micronesia	Net zero	Pledge	CO_2 and other GHGs	Yes
Moldova, Republic of	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Monaco	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Mongolia	No target	No target	No target	No
Montenegro	Climate neutral	In policy	CO_2 and other GHGs	Yes
Morocco	No target	No target	No target	No
Mozambique	Net zero	Proposed	Not Specified	No
Myanmar	Net zero	Proposed	CO_2 only	Yes
Namibia	Net zero	In policy	CO_2 and other GHGs	Yes
Nauru	Net zero	Proposed	CO_2 and other GHGs	Yes
Nepal	Net zero	In policy	CO_2 only	Yes
Netherlands	Climate neutral	In law	CO_2 and other GHGs	Yes

Country Name	Net-Zero Target	Status of Net-Zero Target	Coverage of Net-Zero Target	Has Plan
New Zealand	Net zero	In law	CO_2 and other GHGs	Yes
Nicaragua	Net zero	Proposed	CO_2 and other GHGs	Yes
Niger	Net zero	Proposed	Not Specified	No
Nigeria	Net zero	In law	CO_2 and other GHGs	Yes
Niue	Net zero	Pledge	CO_2 and other GHGs	yes
North Korea	No target	No target	No target	No
Norway	No target	No target	No target	no
Oman	Net zero	In policy	CO_2 and other GHGs	Yes
Pakistan	Net zero	Proposed	CO_2 and other GHGs	Yes
Palau	Net zero	Proposed	CO_2 and other GHGs	Yes
Palestinian Territory, Occupied	No target	No target	No target	No
Panama	Net zero	In policy	CO_2 and other GHGs	Yes
Papua New Guinea	Carbon neutral(ity)	In policy	CO_2 only	Yes
Paraguay	No target	No target	No target	No
Peru	Net zero	In policy	CO_2 and other GHGs	No
Philippines	No target	No target	No target	No
Poland	No target	No target	No target	No
Portugal	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Qatar	No target	No target	No target	No
Romania	Net zero	In policy	CO_2 and other GHGs	Yes
Russian Federation	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Rwanda	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Saint Kitts and Nevis	Net zero	Proposed	CO_2 only	No
Saint Lucia	No target	No target	No target	No
Saint Vincent and the Grenadines	Net zero	In policy	CO_2 and other GHGs	Yes
Samoa	Net zero	Proposed	CO_2 and other GHGs	Yes
San Marino	No target	No target	No target	No
Sao Tome and Principe	Net zero	Pledge	CO_2 and other GHGs	Yes
Saudi Arabia	Net zero	Pledge	CO_2 and other GHGs	No
Senegal	No target	No target	No target	No
Serbia	No target	No target	No target	No
Seychelles	Net zero	In policy	CO_2 and other GHGs	Yes
Sierra Leone	No target	No target	No target	No
Singapore	Net zero	In policy	CO_2 and other GHGs	Yes
Slovakia	Net zero	In law	CO_2 and other GHGs	Yes
Slovenia	Net zero	In policy	CO_2 and other GHGs	Yes
Solomon Islands	Net zero	In policy	CO_2 and other GHGs	Yes
Somalia	No target	No target	No target	No
South Africa	Net zero	Pledge	CO_2 and other GHGs	Yes
South Korea	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
South Sudan	No target	No target	No target	No

Country Name	Net-Zero Target	Status of Net-Zero Target	Coverage of Net-Zero Target	Has Plan
Spain	Climate neutral	In law	CO_2 and other GHGs	Yes
Sri Lanka	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Sudan	Net zero	Proposed	CO_2 and other GHGs	No
Suriname	Net zero	Achieved	CO_2 and other GHGs	yes
Sweden	Net zero	In law	CO_2 and other GHGs	Yes
Switzerland	Net zero	In law	CO_2 and other GHGs	Yes
Syrian Arab Republic	No target	No target	No target	No
Tajikistan	No target	No target	No target	No
Tanzania	Net zero	In policy	CO_2 and other GHGs	Yes
Thailand	Net zero	In policy	CO_2 and other GHGs	Yes
The Bahamas	No target	No target	No target	No
The Gambia	Net zero	In policy	CO_2 and other GHGs	Yes
Timor-Leste	Net zero	Proposed	CO_2 and other GHGs	Yes
Togo	Net zero	Proposed	CO_2 and other GHGs	Yes
Tonga	Net zero	In policy	CO_2 and other GHGs	Yes
Trinidad and Tobago	No target	No target	No target	No
Tunisia	Carbon neutral(ity)	In policy	CO_2 only	Yes
Türkiye	Net zero	In policy	CO_2 and other GHGs	Yes
Turkmenistan	No target	No target	No target	No
Tuvalu	Net zero	In policy	CO_2 and other GHGs	Yes
Uganda	Net zero	In policy	CO_2 and other GHGs	Yes
Ukraine	Carbon neutral(ity)	In law	CO_2 and other GHGs	yes
United Arab Emirates	Net zero	In policy	CO_2 and other GHGs	Yes
United Kingdom	Net zero	In law	CO_2 and other GHGs	Yes
United States of America	No target	No target	No target	No
Uruguay	Net zero	In policy	CO_2 and other GHGs	Yes
Uzbekistan	Carbon neutral(ity)	Pledge	CO_2 and other GHGs	Yes
Vanuatu	Net zero	In policy	CO_2 and other GHGs	Yes
Venezuela, Bolivarian Republic of	No target	No target	No target	No
Vietnam	Net zero	In policy	CO_2 and other GHGs	Yes
Yemen	Net zero	Proposed	CO_2 and other GHGs	Yes
Zambia	No target	No target	No target	No
Zimbabwe	No target	No target	No target	No

Holding the Course — Annual Net-Zero Report 2025

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