Sharing the Effort

Annual Net-Zero Report 2024

ELEVATE
supporting international climate policy

PBL Netherlands Environmental Assessment Agency

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Assessment Agency

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.

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

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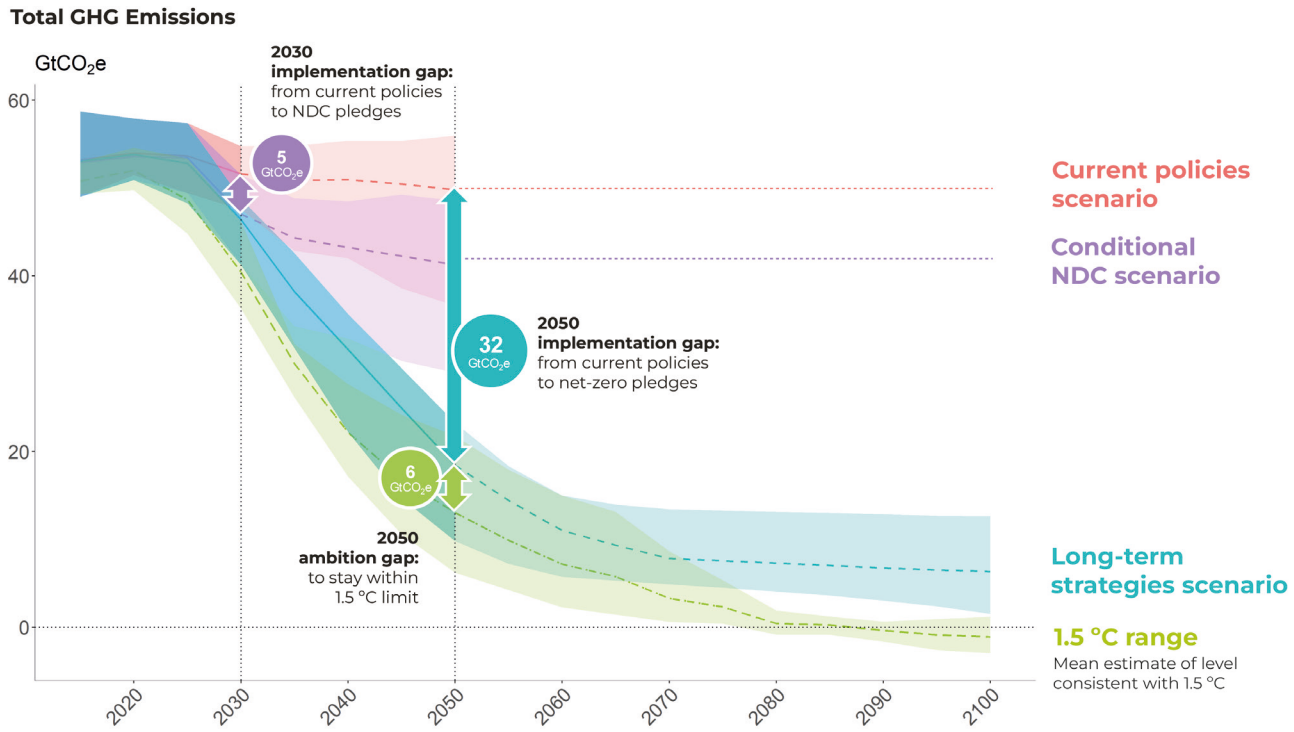
Main Findings



Global GHG emission pathways under various scenarios

This report provides an overview of global climate action following the first Global Stocktake, focusing on current net-zero strategies.

- Current net-zero strategies, if implemented, would reduce 2050 emissions to 18.5 $GtCO_2e$. However, a projected implementation gap of 32 $GtCO_2e$ by 2050 reflects that current policies do not yet reach this level. The ambition gap of 6 $GtCO_2e$ indicates that, taken together, the net-zero pledges are above the 1.5 °C pathway. The pledged NDCs of the EU, US, Brazil, and Japan are aligned with their net-zero targets; this is more difficult to assess for other parties.
- A fair distribution of global emissions reduction responsibilities could be based on equity principles such as equality, capability, and responsibility, leading to significant differences in fair targets between countries. This underscores the need for clear frameworks and transparency in effort-sharing discussions.
- Current policies and NDC projections for several regions do not reach the emission levels consistent with equity principles. This is referred to as a carbon debt. The size of this debt highlights the urgency of more stringent action. One way to address this debt is through international cooperation, as not all targets need to be met domestically.
- Justice considerations are an integral part of scenario design in integrated assessment models (IAMs). In addition to considerations related to emissions trajectories over time and between regions, addressing decent living standards is crucial for ensuring equitable access to energy, which aligns climate action with sustainable development goals. Looking into the various forms and patterns of justice reveals that justice metrics can be expanded, and future studies should move beyond the current emphasis on emissions.
- In the future, it is important that scenarios address the issue of justice more explicitly. This includes looking at the contribution of different parties, evaluating overall economic impacts, poverty reduction, and considering impacts on vulnerable groups.

1. Introduction

Countries around the world have committed to reducing greenhouse gas (GHG) emissions in line with the Paris Agreement's goal of 'limiting global temperature rise to well below 2 °C and pursue efforts to limit it to 1.5 °C' (UNFCCC, 2015a). However, despite these commitments, there remain significant gaps in both the ambition of these targets as well as their implementation. The Global Stocktake, conducted at COP28, highlighted these gaps, signalling the need for more vigorous and coordinated efforts to reduce emissions. The need for clear, measurable pathways towards net-zero emissions has thus become increasingly important.

Chapter 2 highlights the progress and short-comings of current NDCs and net zero targets. The analysis focuses on ambition and implementation gaps, and shows how countries' targets are aligned with the Paris Agreement. This is done for several major emitters, including the EU-27, the US, China, India, and Brazil, as well as Japan and South Africa, which are new to this year's report.

Consensus is needed on how to close both the ambition and implementation gaps. But how to judge whether a Nationally Determined Contribution (NDC) or net-zero target is ambitious enough? Should countries that have emitted large amounts of CO_2 in the past commit to more ambitious targets? Or should countries that have the capacity pay for mitigation? How can less developed countries be supported in their right to sustainable development? These are urgent questions that climate researchers are trying to answer. Key concepts that highlight different justice considerations in climate change mitigation include effort-sharing and, when this cannot be achieved, the idea of net-zero carbon debt. Chapter 3 in this report will explain these concepts in detail and discuss any implications for policy-making.

Achieving net-zero targets cannot be viewed in isolation from the social, economic, and intergenerational impacts that these policies entail. Aside from the discussion around fair shares of mitigation, there are more justice considerations to acknowledge. Chapter 4 discusses three key entry points for integrating these justice perspectives: scenario set-up, core assumptions and mechanisms of models, and scenario interpretation.

Incorporating these justice perspectives is crucial to formulating equitable climate strategies that not only reduce emissions but also promote a just transition. Chapter 5 of this report discusses the research agenda integrating the aforementioned justice considerations with the research of integrated assessment models (IAMs).

This second edition of the ELEVATE Annual Net-Zero Report aims to offer policymakers a clear, evidence-based understanding of where global efforts currently stand and to provide insights into how national and international climate policies can be strengthened to close the gaps identified in this report.

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

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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)
MCC Mercator Research Institute on Global Commons and Climate Change (Germany)
Wageningen University & Research (Netherlands)
WiseEuropa Institute (Poland)
BJUT Beijing University of Technology (China)

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, Chantal Würschinger

The outcome of the first ever Global Stocktake (GST) in Dubai covered the full scope of climate issues and provided direction for the next round of Nationally Determined Contributions (NDCs) due in 2025. Its key findings reiterate how far the world is from achieving the Paris Agreement's goals and emphasise the closing window of opportunity for the deep, rapid, and sustained emission reductions needed (Waskow et al., 2023; Srouji & Cogan, 2023; UNFCCC, 2023a). While the decision to transition away from 'fossil fuels' was the first time the term appeared in a COP's formal outcome since UN climate negotiations began 30 years ago, the consensus also called for action in mitigation, adaptation, and means of implementation and support in the short- and medium-term future (UNFCCC, 2023b).

This report is an update on previous work (van Vuuren et al., 2023) and presents an updated assessment based on multi-model scenario

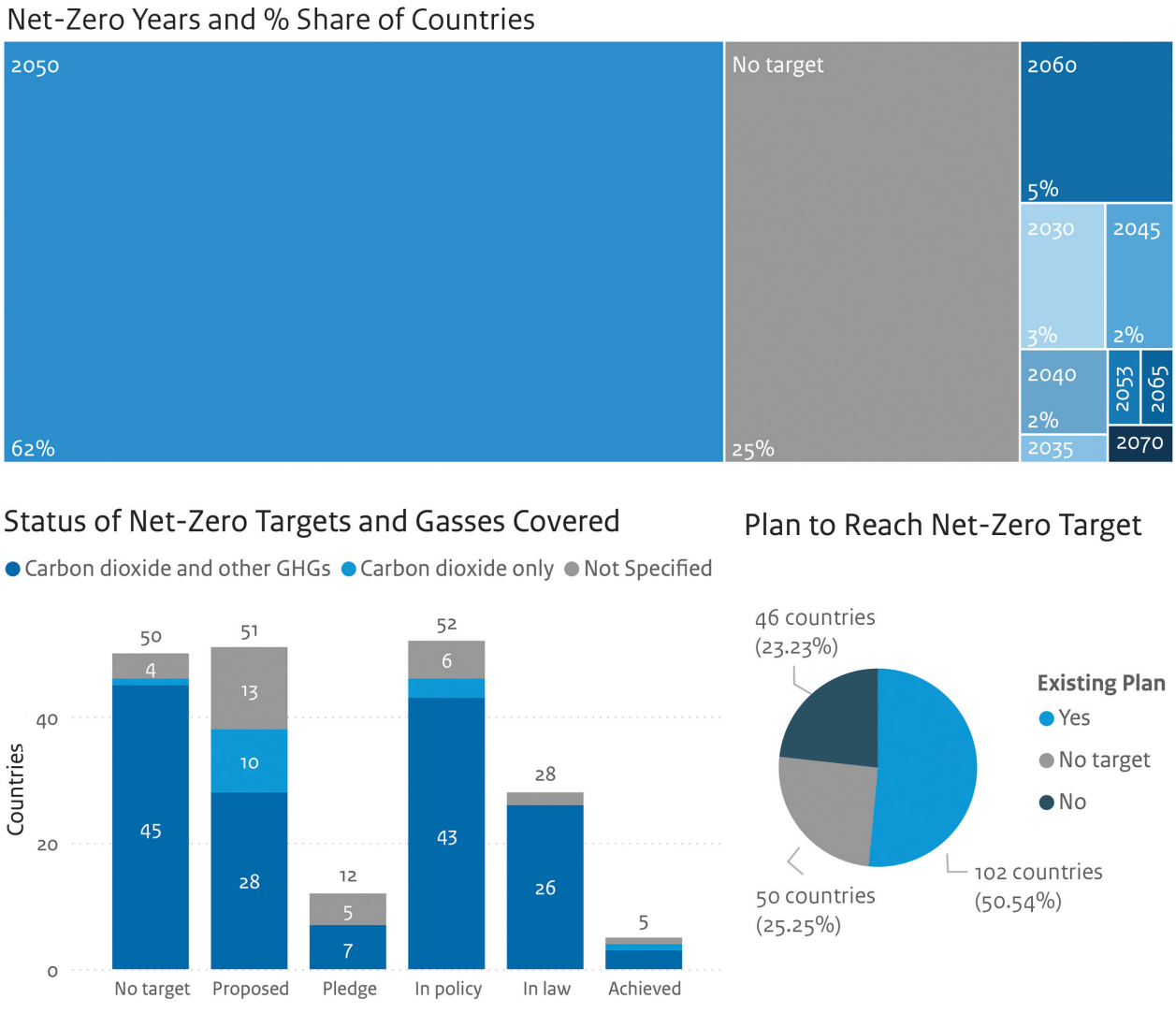

Figure 1: Status of announced net-zero targets, based on data from Net Zero Tracker (2024). 'Proposed' net-zero targets refers to targets that have been proposed but are still discussed. 'Achieved' net-zero targets are self-declared. 'No target' here means no net-zero target. The net-zero target of countries has only one status, e.g. if it is 'pledged', it is not included in 'proposed'.

development and implementation exercise conducted as part of the Horizon2020 ELEVATE project. The report focuses on analysing the 'implementation gap', measuring the alignment between current policies, NDCs, and long-term net-zero goals, and the 'ambition gap', measuring the alignment between the cumulative impact of all long-term net-zero goals and the Paris goals.

Additionally, the list of major emitters for which a more detailed evaluation is performed, is expanded to include Japan and South Africa (alongside the EU-27, the USA, China, India, and Brazil). This country-specific analysis is based on results from IMAGE (Integrated Model to Assess the Global Environment).

2.1. Current status of net-zero announcements

Figure 1 presents the current status of announced net-zero targets. Out of 198 countries that are tracked by the Net Zero Tracker (2024), 149 have a net-zero target that is either proposed, pledged, in policy, in law, or achieved. Out of these countries, 102 countries have published a concrete plan on how to reach their target. The majority of countries have announced their net-zero target for 2050 (62%) and most countries include both CO_2 and other GHGs in their target (72%). Figure 2 shows which countries have a net-zero goal and which emissions their target covers. For a number of countries, it is not specified which gases are covered by the net-zero target.

2.2. Mind the gap

Figure 3 presents the projected emission pathways for four different scenarios, recently updated in the ELEVATE project:

1. Current policies (CPs) scenario: assumes all current adopted policies (legislated policies, executive orders) will be implemented until 2030/2040 (depending on the policy timeline); after 2030/2040 it is assumed a similar effort in climate policies

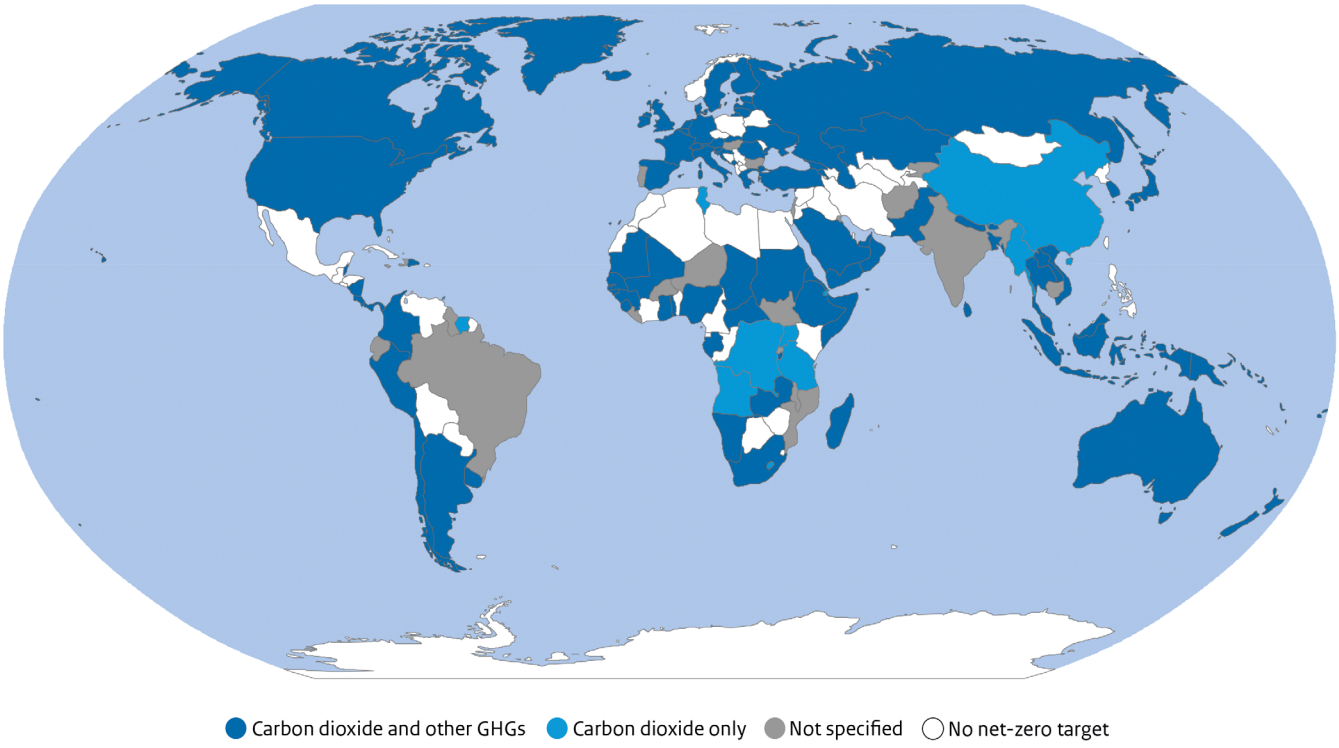

Figure 2: Emissions scope of the net-zero targets per country, based on data from Net Zero Tracker (2024). This figure shows country-level commitments. EU-27 has set a GHG net-zero target for 2050.

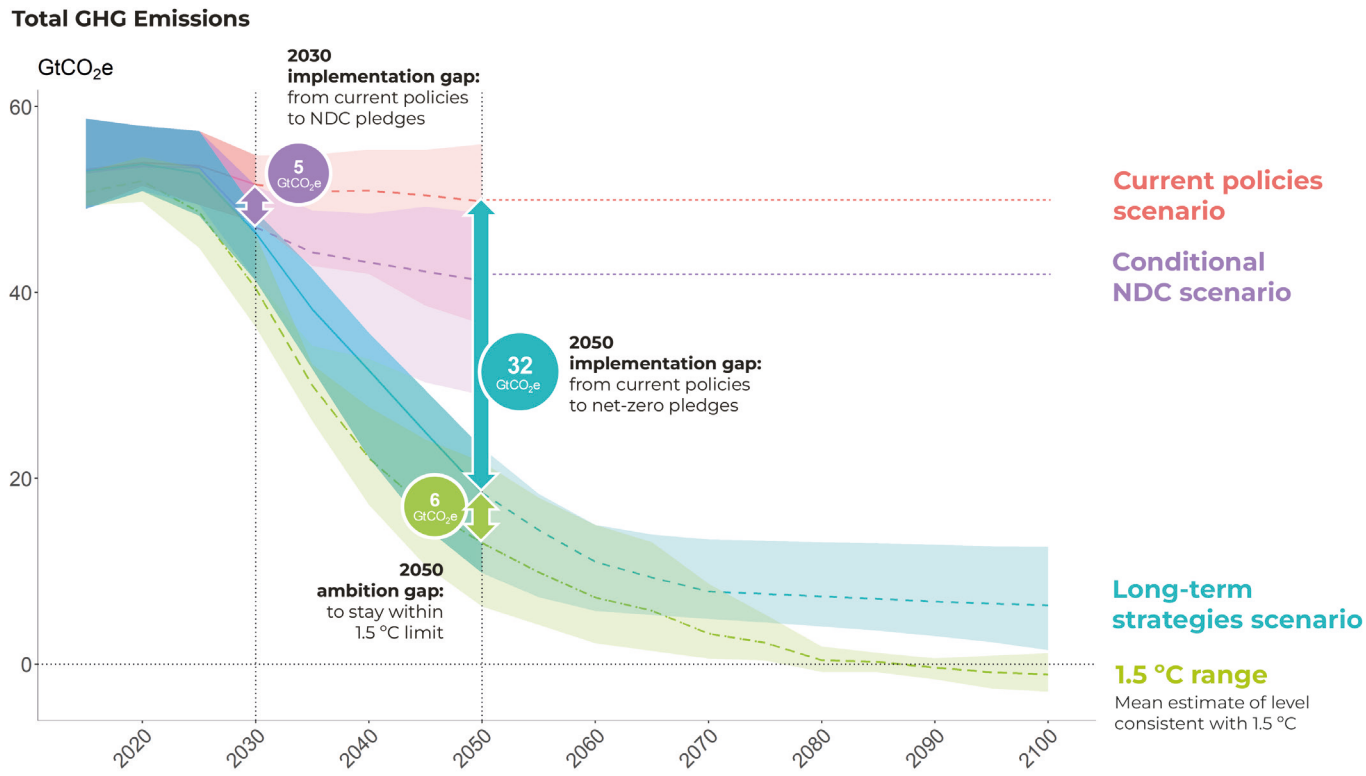

Figure 3: Global GHG emission pathways under various scenarios, and the projected implementation and ambition emission gaps.

will be employed until the end of century.[1]

2. NDC scenario: assumes all NDC pledges will be implemented until 2030; after 2030 it is assumed a similar effort in climate policies will be employed until the end of century.

3. Long-term strategies (LTS) scenario: assumes implementation of all NDC pledges until 2030 and all announced net-zero pledges by each country's respective target year.

4. 1.5 °C scenario: cost-optimal scenario that limits global mean temperature increase to 1.5 °C by 2100.

2.2.1. Implementation gap

In the short term (i.e. 2030), the implementation gap refers to the difference between the current policies' trajectory and the NDCs pathway. In the long term, the implementation gap can also be defined by the expected impact of current policies compared to the collective pledges of the long-term strategies and other announced net-zero pledges (using 2050 as the reference year[2]). The 2030 implementation gap is projected to reach 5 $GtCO_2e$, while the 2050 implementation gap is around 32 $GtCO_2e$ (Figure 3). The implementation gap grows significantly over time as most policies are formulated only for 2030.

2.2.2. Ambition gap

The ambition gap indicates the difference between the overall objective of international climate policy and the sum of all pledges by countries. For the overall goal we look at the cost-optimal 1.5 °C pathway, given the support for this target expressed at the COP26 in Glasgow. In analytical terms, the gap can therefore be defined as the difference in emissions between the trajectory of the combined national long-term strategies (most prominently the announced net-zero pledges) and the estimated levels consistent with a 1.5 °C pathway. The ambition gap for global GHG emissions is projected at 6 $GtCO_2e$ by 2050 (Figure 3).

1 Similar effort is implemented for each region, determining the equivalent carbon price leading to the same emission reductions as current policies or NDCs. Subsequently, this carbon price is applied until the end of the century.

2 2050 is used as the reference year, since 2050 is the most common net-zero year from announced net-zero pledges (see the current status of net-zero pledges in subitem 2.1).

2.3. Tracking major emitters

The following section presents the progress towards long-term targets (net-zero announcements) for seven major emitters: the European Union, the United States, China, India, Brazil, Japan, and South Africa, as based on results from the IMAGE model. In addition, this section provides an assessment of whether the countries' intermediate targets (NDCs) are aligned with each country's long-term goal. Targets differ in ambition level between the various countries. Here, we do not assess ambition levels and fairness of NDCs or net-zero targets, but rather where current emission projections and NDC targets for countries lie in relation to a straight line to their respective net-zero target (Figure 4). In Chapter 3, in contrast, we do bring in fairness considerations.

2.3.1. European Union (EU-27)

In October 2023, the EU submitted a revised NDC to the UNFCCC maintaining its ambition level of reducing emissions to at least 55% below 1990 levels by 2030 (European Council, 2023). Climate neutrality (net-zero target for all greenhouse gases) by 2050 has been enshrined in law since 2021, with a relatively clear structure, transparency and scope, and analysis supporting the target (European Union, 2021).

Over the past year, the EU has finalised the legislation of the Fit for 55 package with the new Energy Efficiency Directive, which was the final step in the legislative process, entering into force in October 2023 (European Union, 2023a). Additionally, 2023 and 2024 saw the establishment of the Carbon Border Adjustment Mechanism (CBAM) (European Union, 2023b) and the Critical Raw Materials Act (CRMA) (European Union, 2024). With its current policies, the EU is on a linear path to its 2050 net-zero target, with projections showing a substantial decrease in emissions by 2030 already. In addition, the NDC target for 2030 is situated on a linear path with the EU-27's net-zero target, meaning that continuation of the same level of effort after 2030 is likely sufficient to achieve GHG neutrality by 2050. To affirm this goal, the EU proposed an intermediate target of a 90% net GHG emissions reduction compared to 1990 levels by 2040 ('the 2040 target') (European Commission, 2024). However, it is important to note that the EU being on a linear path to its targets stands true only if EU-level policies are considered. In the past twelve months, Member States have translated additional EU-level policies into their national contexts (through their National Energy and Climate Plans), but there is still a need to adopt and implement more ambitious policies on a national level to be compatible with the EU's collective targets.

2.3.2. United States (US)

The current US NDC aims at a reduction of 50% to 52% below 2005 emission levels, by 2030 (Government of the United States of America, 2021b). In November 2021, the country also published its long-term strategy, illustrating multiple pathways to reach net-zero GHG emissions by 2050 via investments in clean power, electrification of transportation and buildings, industrial transformation, reductions in methane and other potent non-CO_2 climate pollutants, and land-use sinks (Government of the United States of America, 2021a).

Under current policies, the country is projected to steadily decrease emissions until 2050, but there is some uncertainty regarding the rate of decline. Recent regulations from the Environmental Protection Agency (EPA) have introduced new vehicle emissions standards for 2027 onwards, as well as several regulations on tighter carbon emissions limits affecting fossil fuel power plants (EPA, 2023, 2024). At the same time, the US reached record-high oil and gas production and exports and is planning to increase its liquified natural gas export capacity (EIA, 2019). Still, the US NDC target itself is positioned on a linear path to the country's net-zero target; the continuation of GHG emission reductions at the same rate after 2030 will be enough to achieve the 2050 GHG neutrality target.

2.3.3. China

China submitted its updated NDC in October 2021, revising its four separate NDC targets and adding a fifth target to increase renewable capacity. China also submitted its official long-term strategy in

the same month, with a commitment to reach net-zero by 2060, although the document lacks details in bunker emission coverage, removal targets, and other related sectors (Government of China, 2021).

China is expected to achieve its 2030 renewable energy capacity target of 1200 GW this year, with an expected capacity of 1340 GW by the end of 2024 (IEA, 2024b; NEEC, 2023). Emissions are projected to peak before 2030 under current policies. Current projections, as well as the NDC target of China are above a linear path to its net-zero target.

2.3.4. India

India's updated (conditional) NDC was submitted in August 2022 and is aimed at decreasing the GHG emissions intensity by 45% below 2005 levels as well as at increasing the share of non-

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	NDC aligned with net-zero target
EU-27	Net-zero GHG by 2050	EU-27's current projections are on a linear path to its net-zero target	Reduce GHG by 55% below 1990 levels by 2030	EU-27's NDC is on a linear path to its net-zero target
US	Net-zero GHG by 2050	USA's current projections are not on a linear path to its net-zero target	Reduce GHG by 50–52% below 2005 levels by 2030	USA's NDC is on a linear path to its net-zero target
China	Carbon-neutral by 2060 (type of gas not specified)	China's current projections are not on a linear path to its net-zero target	Peak CO_2 before 2030, lower carbon intensity by over 65% by 2030 from 2005 levels, and other targets	China's NDC is not on a linear path to its net-zero target
India	Net-zero by 2070 (type of gas not specified)	India's current projections are not on a linear path to 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 to its net-zero target
Brazil	Climate-neutral by 2050 (type of gas not specified)	Brazil's current projections are not on a linear path to its net-zero target	Reduce GHG by 53.1% below 2005 levels by 2030	Brazil's NDC is on a linear path to its net-zero target
Japan	Net-zero GHG by 2050	Japan's current projections are on a linear path to its net-zero target	Reduce GHG by 46% below 2013 levels by 2030	Japan's NDC is on a linear path to its net-zero target
South Africa	Net-zero carbon emissions by 2050 (type of gas not specified)	South Africa's current projections are not on a linear path to its net-zero target	Limit GHG emissions to 350–420 $MtCO_2e$ by 2030	South Africa's NDC positioning with respect to a linear path to its net-zero target depends on the NDC range boundaries (see country description)

fossil energy capacity in the power sector to 50% by 2030 (Government of India, 2022b). India announced its net-zero target for 2070 during COP26 as part of its long-term strategy, but it has not yet been approved in parliament and the gas coverage is still unclear. The country expects coal to play an important role in its future energy production and supply (Government of India, 2022a).

Emissions under existing policies in India are expected to increase at a similar rate as in the past decade and show no signs of peaking before 2030. The country is on track to meet its NDC targets, but both current projections and the NDC target are not on a linear path to India's net-zero year.

2.3.5. Brazil

Brazil submitted its updated NDC in October 2023, increasing its ambition level from 50% to 53.1% below 2005 levels by 2030. The update reiterates claims that it sets the country on a pathway compatible with climate neutrality by 2050. However, no further details or clarifications on the scope or pathway of said neutrality goal have been provided by the government, and it remains unlegislated (Climate Action Tracker, 2023a).

Brazil's current projections are not on a linear path to its net-zero target. With most of the country's emissions coming from the land-use sector, achieving the net-zero target will highly depend on increasing the ambition level and enforcement of land-use related policies in the short term. Brazil will be well situated to achieve its net-zero target if it achieves its NDC goal, as the NDC is on a linear path to the country's long-term target.

2.3.6. Japan

The NDC for Japan sets a target of 46% reduction in GHG emissions by 2030 compared to 2013 levels (Government of Japan, 2022). Additionally, its 2050 net-zero target covers all emissions and economic sectors and is enshrined in domestic law. However, the emission pathway to net-zero post-2030 lacks clarity on separate emission reduction and removal targets (Climate Action Tracker, 2023b; Government of Japan, 2021).
Japan's current projections are on a linear path

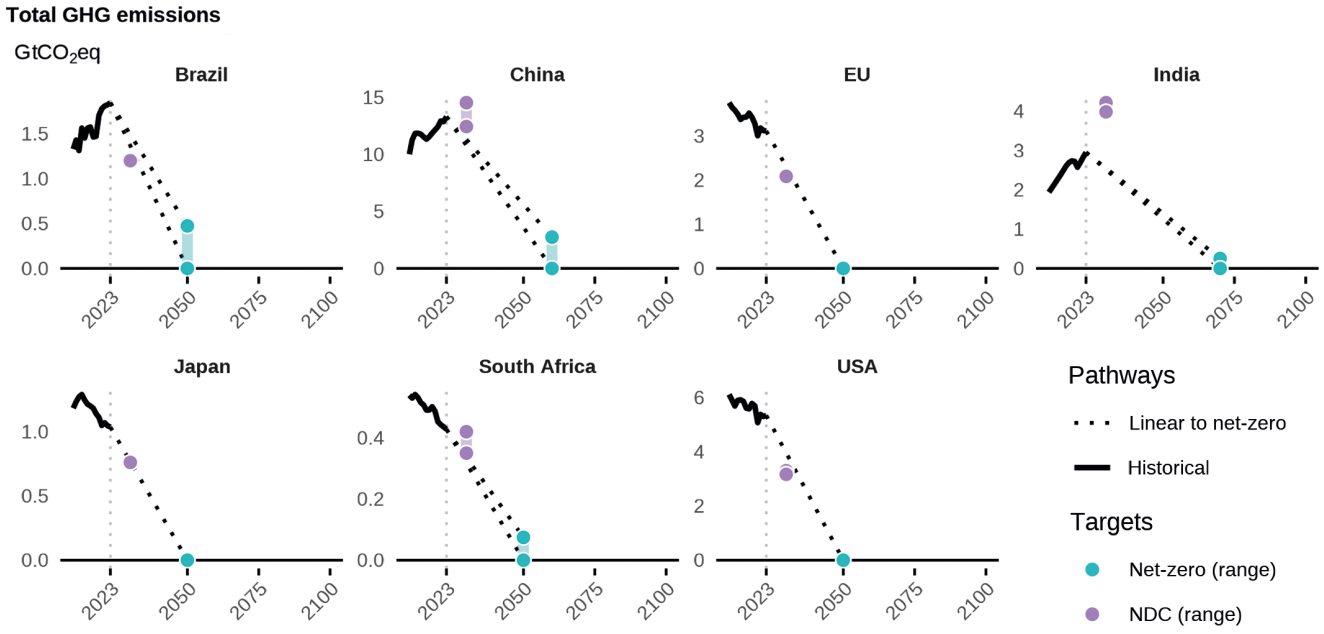

Figure 4: Linear GHG emission pathways from 2023 levels to net-zero targets, and 2030 GHG levels based on NDCs. Historical data comes from national inventories submitted to the UNFCCC (n.d.), supplemented by harmonized IMAGE model data where needed. NDC emission levels follow den Elzen et al. (2024). For net-zero targets covering only CO_2 (or unclear coverage), GHG emissions at net-zero CO_2 are estimated using the latest ratio of non-CO_2 to total GHG emissions from national inventories.

to its NDC target as well as its announced GHG neutrality targets. Emissions have been on a downwards trajectory for the past ten years and, if the NDC emission target levels are met, only a very modest additional effort (amounting to 20-30 $MtCO_2eq$ reductions) is required as the NDC target is on a linear path to the 2050 neutrality target.

2.3.7. South Africa

South Africa's updated NDC was submitted in 2021, with targeted emission levels between 350-420 $MtCO_2eq$ in 2030 (Government of South Africa, 2021). The country has only communicated a preliminary long-term strategy that mentions reaching net-zero emissions by 2050, without specifying the gas coverage. The available information indicates a lack in scope, architecture, and transparency for South Africa's target (Climate Action Tracker, 2023c).

The significant range of emission levels in its NDC is a major uncertainty factor in assessing whether South Africa's NDC is on a linear path to its net-zero target. The lower range puts the country on an emissions pathway in line with its LTS target (and even a cost-optimal 1.5 °C pathway), but the upper range suggests a continuation of emissions at the current level. In any case, under existing policies, South Africa is not on a linear path to its net-zero target and needs to increase ambition to overcome its dependency on coal energy generation (Climate Action Tracker, 2023d).

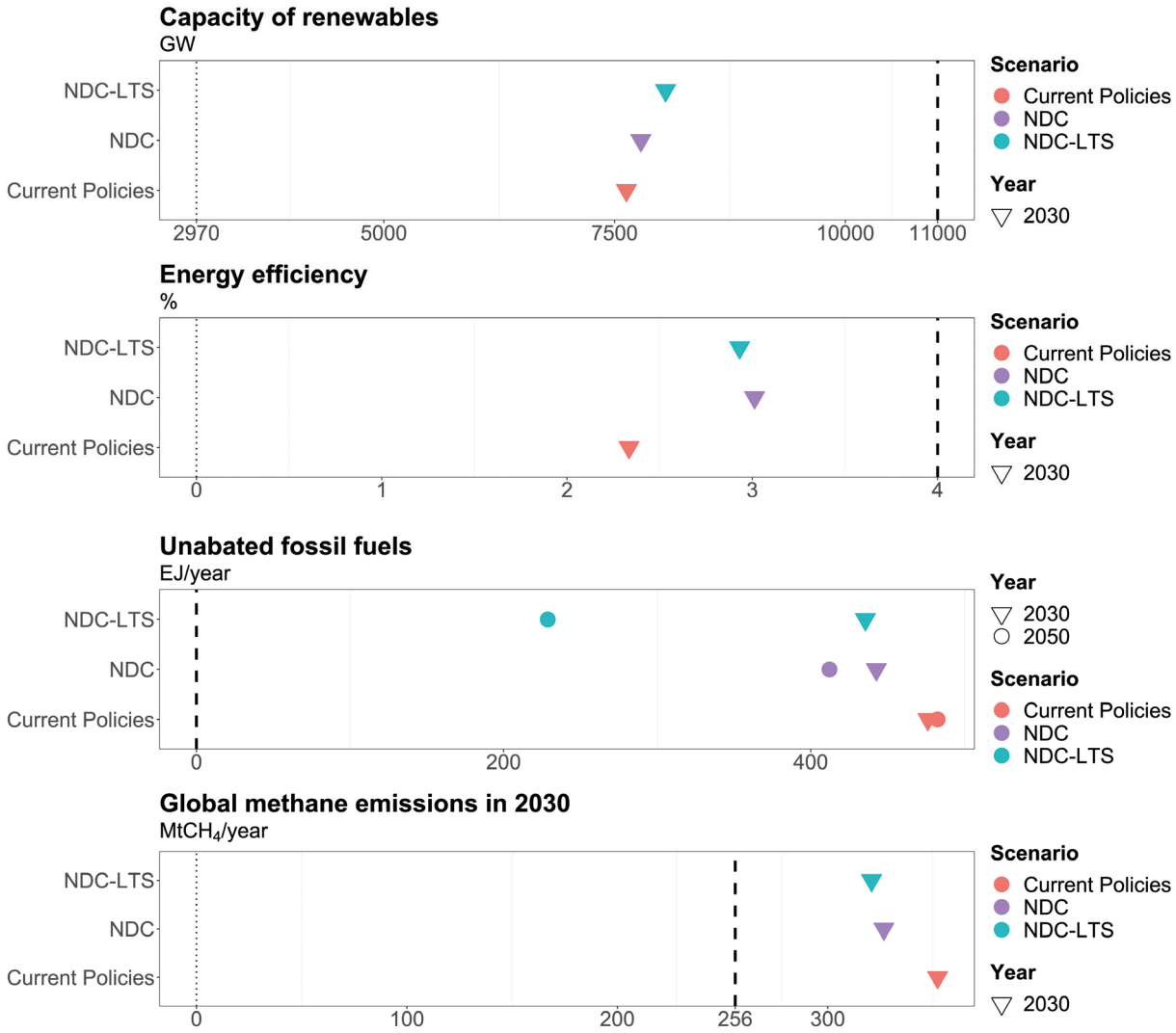

Figure 5: Outcomes of the Global Stocktake (GST). From the top: renewable energy capacity, energy efficiency, phasing out/down unabated fossil fuels, global methane emissions. The bold, dashed line marks the GST goal. Levels under Current Policies, NDCs, and NDC-LTS are based on scenarios recently updated as part of ELEVATE.

2.4. Outcomes of the 1st Global Stocktake

During COP28, in Dubai, the 1st Global Stocktake (GST) concluded that current climate action is insufficient to fulfil the Paris Agreement goals. In its consensus (UNFCCC, 2023a), Paragraph 28 calls on countries to contribute to the global efforts and highlights important steps to increase ambition. This report focuses on the following recommendations:

- Tripling global renewable energy capacity by 2030;
- Doubling global average annual rate of energy efficiency improvements by 2030;
- Transitioning away from fossil fuels;
- Substantially reducing non-CO_2 global emissions, particularly methane emissions, by 2030.

Climate policy scenarios recently updated as part of ELEVATE show that under the current ambition of NDCs, reaching such goals is challenging (Figure 5). For renewable energy capacity, energy efficiency[3], and reducing methane emissions, the short-term goals are not met, indicating that, on a global level, NDCs are not aligned with a 1.5 °C pathway. For the phase-out/down of fossil fuels, results show significant residual unabated fossil fuel use under current policies and NDCs. However, when net-zero commitments are accounted for (NDC-LTS), a considerable reduction in the participation of fossil fuels in the energy mix can be seen around and beyond mid-century.

KEY FINDINGS

- The net-zero pledges are projected to result in an emission level of 18.5 $GtCO_2$ in 2050. The projected implementation gap by 2050 is approximately 32 $GtCO_2e$. The implementation gap emphasises the urgent need for nations to enhance their climate policies to meet their net-zero targets.
- The ambition gap to achieve a 1.5 °C compatible pathway is projected to be 6 $GtCO_2e$ by 2050. This indicates that the cumulative effect of announced net-zero pledges is insufficient to align with the goals of the Paris Agreement, requiring countries to heighten their ambition.
- Four of the seven major emitters (Brazil, EU-27, Japan, and the US) have an NDC that is on a linear emissions reduction trajectory towards their net-zero targets.
- ELEVATE's global modelling results support the outcomes of the first Global Stocktake (GST): current ambition is insufficient and rapid and sustained emission reductions are needed to align with the Paris goals.

3 We calculate energy efficiency in terms of energy intensity (TPES/GDP) improvement rates, consistent with IEA and IRENA reports (IEA, 2024a; IRENA, 2023). Based on this, we use the 4% annual improvement rate for energy efficiency as the minimum required for reaching the doubling goal.

3. Fairness and Emissions Targets

Mark Dekker, Setu Pelz, Chantal Würschinger

3.1. Concepts and considerations

Mitigating the cause and impacts of anthropogenic climate change is high on the global agenda. The distribution of mitigation efforts, however, remains highly debated. Undoubtedly, equity is an important factor to consider when allocating emission reduction goals, among others. As part of the Paris Agreement, countries have committed to 'reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances' in their mitigation efforts, among other considerations (UNFCCC, 2015a).

The Paris Agreement leaves room for sovereign interpretation as to which allocation of the mitigation burden reflects principles invoked in the Agreement. In the decades of scientific literature since the inaugural IPCC assessment report in 1990, a range of allocation approaches have been proposed, aligning to various degrees with interpretations of principles drawn from international agreements. Commonly referenced interpretations of these principles include equality (every person has equal rights under equal conditions), capability (those with greater

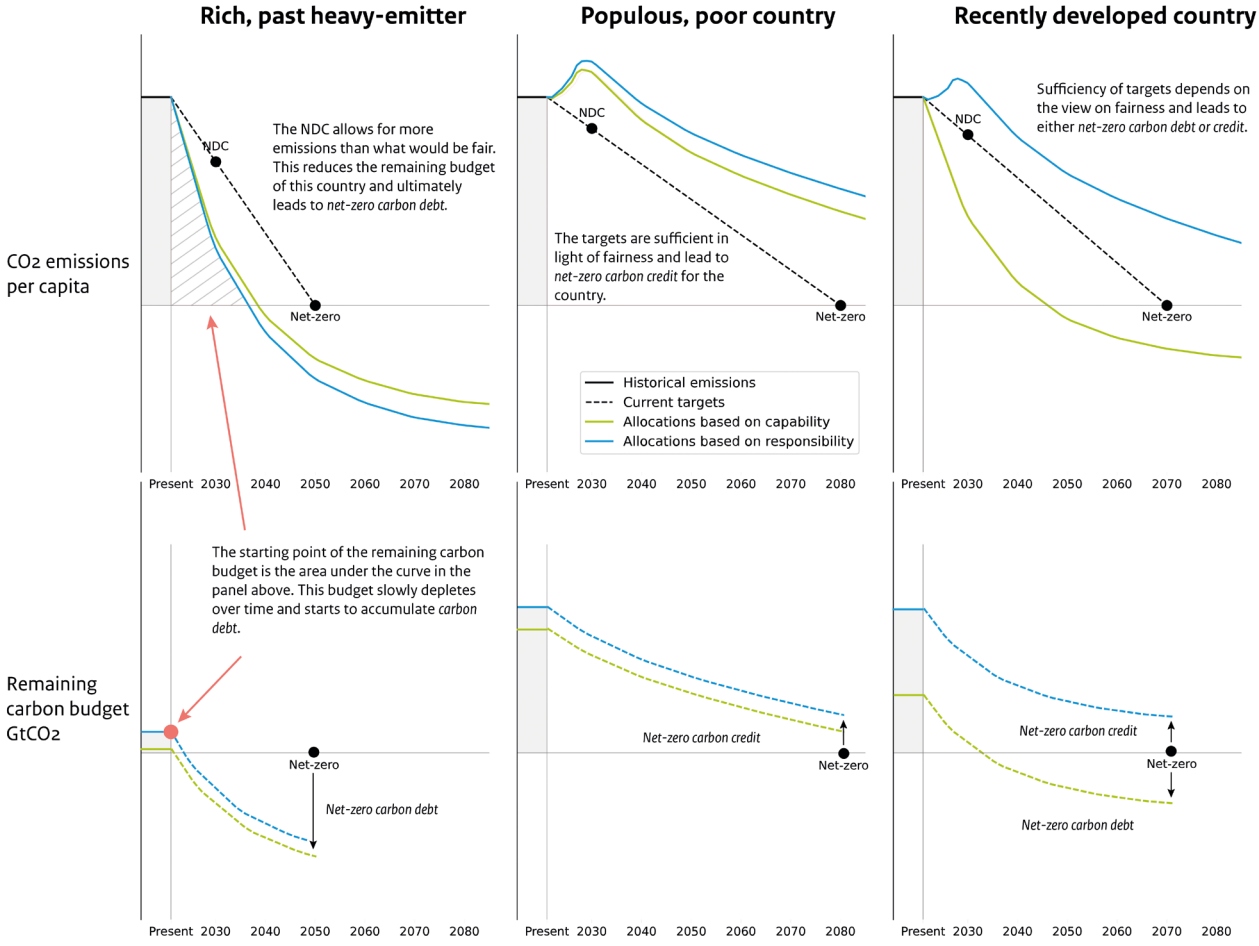

Figure 6: Conceptual illustration for three fictitious countries. A dashed line shows each country's linear pathway from current levels to 2030 NDC and net-zero targets. The upper panel displays 'fair' emissions pathways in two fairness interpretations: capability (green) and responsibility (blue). The lower panel shows net-zero carbon debt accrual, based on initial allocations aligned with these fairness principles, with their consumption to net-zero also marked by a dashed line.

ability to pay should bear more mitigation costs), responsibility (those who have contributed the most to climate change should pay more), and the right to sustainable development (every human should have their basic needs met) (Clarke et al., 2014; Dooley et al., 2021). In turn, these interpretations can be quantified in various ways by making use of allocation rules – mathematical equations that distribute the global carbon budget among countries through weighing population, wealth, and historical emissions, for example (van den Berg et al., 2020; Robiou Du Pont et al., 2017; Dekker et al., 2024a). These analyses yield quantitative 'fair shares' of the global carbon budget for every country in the world, or, when detailing individual years, fair national emissions pathways.

Figure 6 illustrates how these concepts might apply to different countries. Although each fairness principle is shown by a single line, in reality, uncertainties complicate the results, often preventing clear-cut conclusions of whether or not a country is on a 'fair' track. Spread in fair emissions estimates stems from many different sources (Dekker et al., 2024a; Robiou Du Pont et al., 2017). First and foremost, normativity in one's view on fairness plays a dominant role in these computations. Not only which principle to choose to fairly allocate emissions (e.g., the green or blue line in Figure 6), but also more detailed parameters such as how discounting past emissions can have a major impact on these numbers. Secondly, global (political) discussions— such as the choice of temperature goal, the emissions sectors to include, and global non-CO_2 targets—play a significant role. Finally, scientific uncertainties, including socio-economic projections and climate sensitivity, further obscure fair emissions estimates.

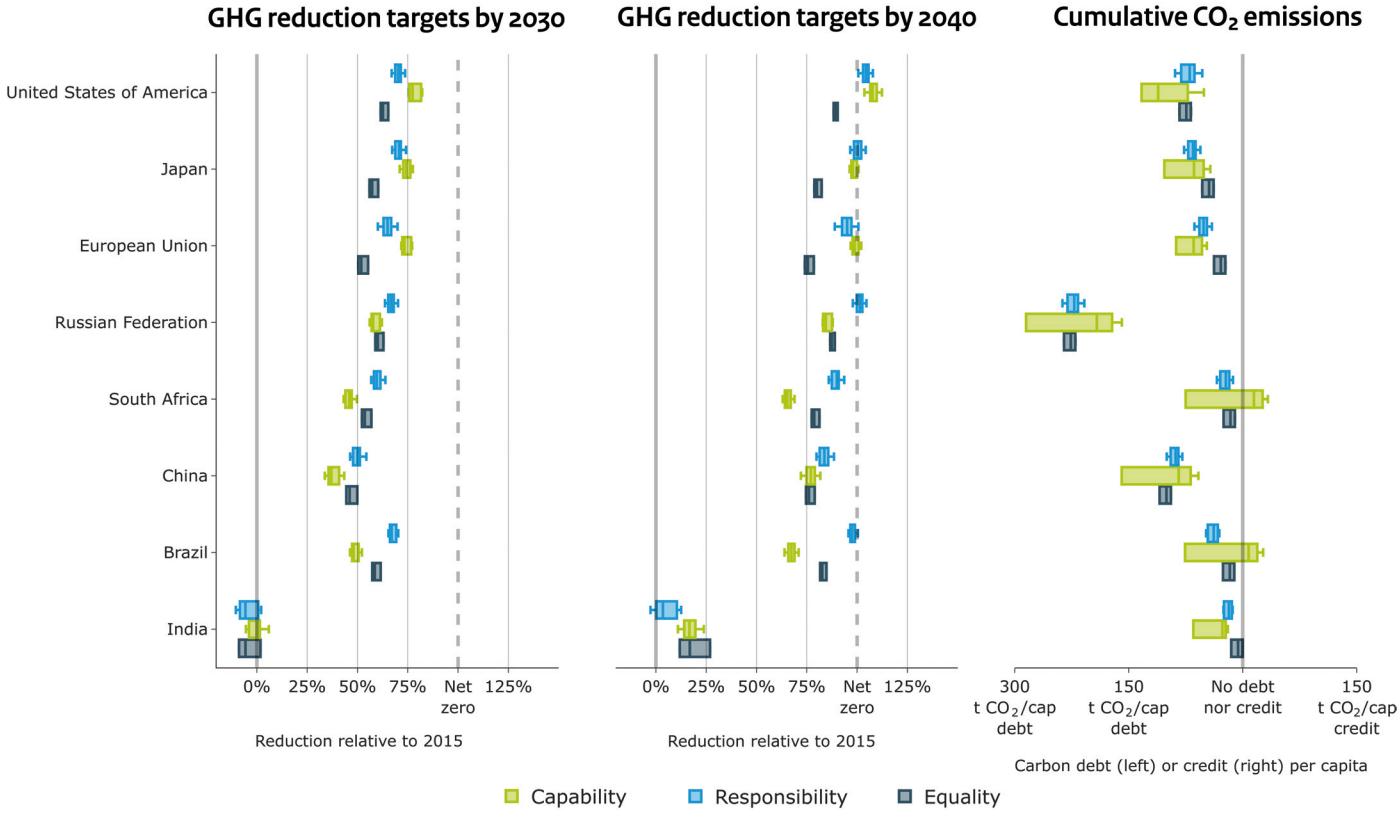

Figure 7: Fair reduction targets for selected countries. Ranges are based on allocation rules of capability (green), responsibility (light blue), and equality (dark blue) for 2030 targets (left), 2040 targets (middle), and cumulative CO_2 reductions from 2021 to 2050 (right). Note that other reports, such as ESABCC (2023), use 1990 as a reference year. The latter estimate includes net-zero carbon debt by subtracting the policy pathway to net-zero CO_2 based on IMAGE model output with ELEVATE T2.3 scenarios. Targets assume a global temperature goal of 1.6°C (50% probability), a 33-67 percentile range for non-CO_2 reductions, and vary by socio-economic scenarios. Detailed data and parameters can be found in Dekker et al. (2024b).

As also shown in Figure 6, one can compare mitigation effort 'fair shares' with current targets; not only in individual years (e.g. to evaluate NDCs in 2030), but also in a cumulative sense. This illustrates the concept of net-zero carbon debt (Pelz et al., 2024; Matthews, 2016): the extent to which historical and future emissions exceed 'fair share' allocations, up to the net-zero year. Measuring carbon debt accrual informs the safe and equitable return to 1.5 °C following overshoot in two ways. Firstly, it links near-term action with relative responsibility for global temperature overshoot, where each year of insufficient action steadily grows carbon debt, which eventually contributes to climate overshoot. Secondly, it links net-zero targets with necessary 'fair' carbon dioxide removal (CDR) during overshoot, making explicit the intergenerational transfer of burden and required CDR scale-up. This is also evident in the negative emissions components of the 'fair share' emissions pathways shown. This dual near-term and net-zero target assessment can thus inform both mitigation targets and removals targets under a Party's normative understanding of fairness, naturally leading to considerations of domestic feasibility and international contribution. A webtool is available to explore this concept further: https://data.ece.iiasa.ac.at/carbondebt/.

3.2. Key outcomes

Figure 7 illustrates key outcomes of the analysis for a number of major emitter countries and the European Union, accounting for the two most commonly mentioned interpretations of principles invoked in the Paris Agreement, linking to the CBDR principle: capability (green) and responsibility (light blue), as well as equality (dark blue). Key outcomes are fair GHG reduction targets in 2030 (left), 2040 (middle), and net-zero carbon debt (comparing 'fair' allocations to expected cumulative CO_2 emissions based on IMAGE model output with ELEVATE T2.3 scenarios). The overall range of outcomes for a single country (notably Brazil and India) is striking; the aforementioned dimensions of normative and scientific uncertainty yield notably different outcomes.

Despite this, some robust insights emerge. Fair estimates suggest the US and EU need to reduce GHG emissions by about 100% by 2040. Russia and Japan show similar patterns, while South Africa has less stringent targets along the capability principle (green). Brazil, India, and China differ, showing generally smaller reductions but with wider ranges. Some estimates for India even suggest a temporary emissions increase from 2015 to 2030, while others indicate reductions.

To the right, we see the results of comparing fair cumulative CO_2 emissions to national emissions pathways that align with current net-zero ambitions. Negative values (left of the dashed line) indicate carbon debt, while positive values indicate carbon credit. Substantial debt can be recognised among most of these major emitters. The results reiterate existing findings on this topic (Pelz et al., 2024).

CARBON BUDGET EXPLORER

The 'Carbon Budget Explorer' is a free and open-source online dashboard that allows users to explore climate targets under different conditions around the globe, as well as various climate policy pathways and how differing views on fairness lead to different emission allocations for individual countries. It offers projections of emissions under current policies, NDCs, and net-zero pledges, showing how they align with climate targets. Users can assess emission gaps and explore various effort-sharing methods based on a carbon budget. Policymakers, scientists, and stakeholders are encouraged to use the dashboard for detailed, interactive country-level data, which can aid negotiations and improve access to policy-relevant information.

The "Carbon Budget Explorer" is developed by PBL in collaboration with the Netherlands eScience Center.
Website: www.carbonbudgetexplorer.eu

3.3. Consequences for policymaking

Fair emissions allocations vary significantly, as shown by the wide ranges in Figure 7. This raises questions about how useful these results are for policymaking, as countries could choose the most favorable outcome. First, Dekker et al. (2024a) showed that comparing 'fair shares' with NDCs reveals a list of countries with insufficient ambitions under any uncertainty range. They also indicate that strong gradients between Global North (greater reductions) and Global South (smaller reductions) are robust.

Secondly, these ranges highlight how normativity and uncertainty shape the debate on sharing mitigation efforts. This highlights that key discussions should focus on the exact temperature target (1.5 °C, 1.7 °C, or 2.0 °C) and non-CO_2 targets, as well as how to interpret Paris Agreement principles through national constitutions and relevant legislation like the European Climate Law (ESABCC, 2023). Clarity and transparency on these considerations would lead to a more open discussion on sharing the efforts.

While carbon debt and effort-sharing pathways are sometimes interpreted as separate concepts, this chapter reaffirms how they are strongly connected (e.g. see Figure 6) and are in fact different sides of the same coin. Effort-sharing pathways illustrate a possible 'fair' trajectory to meet intermediate targets in, for example, 2030 and 2040, and net-zero carbon debt describes the implications of not meeting these for overshoot and carbon drawdown responsibility. Both are consistent in their operationalisation of allocation approaches and can be applied as necessary for a given policy debate.

Note that some of the results are more stringent than what is commonly considered feasible. For many Global North countries, fair reduction targets far exceed domestic cost-optimal reductions, making it extremely expensive to mitigate these emissions domestically (ESABCC, 2023; Dekker et al., 2024a). Investing in mitigation abroad, potentially in countries with less stringent fair targets, would be economically more efficient. However, it remains critical to maximise domestic mitigation to the greatest extent possible. In the absence of an internationally recognised carbon trading (e.g. along the lines of Article 6 of the Paris Agreement), tracking foreign mitigation efforts presents significant challenges. Thus, domestic mitigation should be prioritised, with foreign investments being a potential solution beyond (economically) feasible targets.

KEY FINDINGS

- A fair distribution of global emission reduction responsibilities could be based on equity principles such as equality, capability, and responsibility, leading to significant differences in fair targets between countries. This underscores the need for clear frameworks and transparency in effort-sharing discussions.
- Based on the principles of capability and responsibility, major emitters like the US and EU would need to reduce GHG emissions in line with the 1.5 °C target by around 100% in 2040. For Brazil, India, and China, the results show a wider range.
- Carbon Debt and Mitigation Link: Net-zero carbon debt links historical emissions to future responsibilities, emphasising the need for effective carbon dioxide removal strategies.

4. Broader Justice Perspectives

Jarmo Kikstra, Elina Brutschin, Keywan Riahi

Despite the complexity and abstract nature of justice as a concept, many elements of the scenario design process that lead to quantitative climate mitigation pathways are inherently tied to justice considerations. With this term we refer to both theoretical concepts of justice and more normatively grounded evaluations of fairness. In Figure 8, we illustrate that within the context of global IAMs, there are three key entry points for integrating justice considerations: (1) Scenario set-up, where inputs consist of a mix of quantitative exogenous variables—typically focused on socio-economic trajectories—and qualitative narratives that describe the general nature and conditions of future developments; (2) Core assumptions and mechanisms of the model, such as the optimisation function, discount rates, or key constraints on certain technologies; and (3) Scenario interpretation, which may involve additional ex-post quantitative evaluations or more qualitative interpretations of the results.

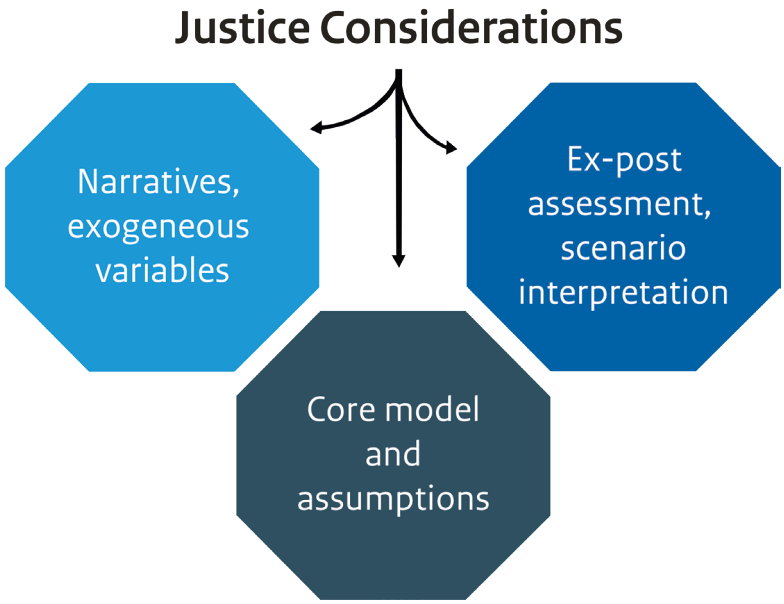

Figure 8: Entry points for justice considerations.

There is a broad, well-established body of literature on the concept of justice, particularly in relation to environmental justice and research on socio-ecological transitions (e.g. Lazarus, 1993; Mohai et al., 2009). An explicit treatment of justice concerns within the IAM research has so far focused mainly on an ex-post interpretation of the IAM outputs in the context of emissions (van den Berg et al., 2020; Höhne et al., 2014; Williges et al., 2022), and investments (Pachauri et al., 2022). There are, however, growing efforts in translating different streams of literature and disciplinary concepts in the context of Earth System Justice (Gupta et al., 2023) and justice in global pathways (Zimm et al., 2024; Hanger-Kopp et al., 2024). An emerging question in this context is which elements of the many justice considerations can be operationalised directly in IAMs, and which should be addressed outside the modelling framework (Low et al., 2024).

The Earth System Justice framework (Gupta et al., 2023) proposes focusing on three key dimensions of justice: (1) Interspecies, (2) Intergenerational, and (3) Intragenerational justice. This broader perspective includes biodiversity considerations, moving beyond the traditional focus on human-centred intergenerational and intragenerational justice. Zimm et al. (2024) summarise tools for integrating justice considerations by highlighting

various forms of justice — distributional, procedural, corrective, recognitional, and transitional — along with different justice patterns, such as Utilitarian, Egalitarian, Prioritarian, Sufficientarian, and Limitarian (Table 2). Crucially, they emphasise that justice metrics (i.e. what is being distributed) can be substantially expanded in climate mitigation research, and future studies should extend beyond the current emphasis on emissions. Overall, both frameworks provide substantial conceptual guidance for the IAM community in broadening justice considerations within their models.

Going beyond emissions, the Decent Living Standards (DLS) literature brings an understanding of multidimensional needs to climate scenarios and presents one of the key avenues to explore and address broader justice considerations directly in the IAMs. The Paris Agreement (UNFCCC, 2015a, p. 1) emphasises a strong connection between climate action and sustainable development, as well as the eradication of poverty.
DLS is an operationalisation of the call to 'leave

Table 2: Forms and patterns of justice from Zimm et al. (2024).

Form of justice	Options for expansion	Examples of future work
Distributional	• Expand domain coverage • Investigate different patterns and combinations of patterns • For different metrics and indicators at more granular scopes and with different regional configurations • Include in narratives	*Utilitarian:* Expand utility/welfare to include different aspects of human well-being Prioritarian: Different groups being served beyond efficiency considerations *Egalitarian:* Per capita and Gini coefficient (reductions in Gini) of different indicators (beyond gross domestic product and green-house gases) *Sufficientarian*: Minimum levels of different indicators *Limitarian*: Caps/upper limits of different indicators
Procedural	• Transparency about objectives and underlying assumptions • More and broader stake-holder involvement • Greater diversity in research teams	*Model design:* Share underlying assumptions and their potentially different impacts with regard to justice questions *Scenario development:* Discuss regional/national choice and preference for metrics and pat-terns with stakeholders
Corrective	• Include in individual sce-nario application narrative • Inclusion of compensatory payments	Can be restorative and compensatory Combined with distributional justice, modify patterns considering historical contributions or inclusion of compensatory payments, reflecting historical responsibility
Recognitional	• Acknowledgement of issues	Using trusted locals to communicate climate policy or suggest contextually sensitive ways to implement policy or design scenarios
Transitional	• Different policy sequencing options for different metrics and patterns	Introducing initial rebate cheques before fully implementing carbon pricing

no one behind', through ensuring the availability of minimum services for all, thus including elements of sufficientarian and prioritarian justice patterns. These services include, among others, adequate nutrition, durable homes with good living conditions, healthcare, education, and mobility. Currently, DLS deprivations are widespread, with sub-Saharan African countries seeing on average over 60% of the population deprived in more than half of the indicators (Kikstra et al., 2021).

Most mature is the research on minimum energy needs, which has found that the energy required to meet DLS for all is less than half the current global energy footprint (Millward-Hopkins et al., 2020; Kikstra et al., 2021). On top of that, if energy efficiency of service provisioning systems increases, energy needs could decrease over time. Nevertheless, the challenge to close decent living gaps worldwide is large, requiring unprecedented energy growth rates in many countries, as well as more equitably distributed growth (Kikstra et al., 2021; Millward-Hopkins, 2022).

The magnitude of the transformation required to reduce emissions is determined strongly by energy demand pathways. Low demand pathways feature multiple benefits (Bento et al., 2024; Grübler et al., 2018). Therefore, considering energy equity, including DLS, thus asks for a combination of strong demand reductions in high-resource use countries with strong energy provisioning increases in poorer countries. Closing residential decent living gaps while meeting climate goals is possible, under very strong efficiency improvements and unprecedented global inequality reductions (Kikstra et al., 2024; Soergel et al., 2024). Under such pathways, the emissions implied in providing energy for DLS for all (during 2023-2050) are less than 200 $GtCO_2$, a quarter of which would take place in the Global South (Kikstra et al., 2024). Future work can further investigate how ensuring minimum resource availability for each country in the world affects the timing of regional energy transformations emissions reductions in scenarios.

KEY FINDINGS

- Integration of Justice in IAMs: Justice considerations are essential when climate mitigation pathways with Integrated Assessment Models (IAMs), focusing on scenario setup, model assumptions, and scenario interpretation.
- Expanding Justice Dimensions: The Earth System Justice framework identifies three dimensions — interspecies, intergenerational, and intragenerational justice — highlighting the need for broader justice metrics beyond emissions.
- Forms of Justice: Looking into the various forms and patterns of justice reveals that justice metrics can be expanded, and future studies should extend beyond the current emphasis on emissions.
- Decent Living Standards (DLS) Framework: The DLS framework provides a way to analyse the interaction between the satisfaction of human needs, resource needs, and climate action, addressing sufficientarian and prioritarian justice patterns.
- Energy Demand Pathways: Achieving climate goals while closing decent living gaps requires balancing strong demand reductions in high-resource countries with energy provision increases in poorer nations, unprecedented efficiency improvements and reduced global inequality.

5. Outlook: An Agenda for the Future

Detlef van Vuuren, Benjamin Sovacool, Elmar Kriegler, Keywan Riahi

As noted in earlier chapters, justice and equity play a major role in the distributional questions around emission reductions and climate change impacts. This is particularly true in the current situation, marked by high inequality between countries and societal groups. For example, there are significant differences in both contributions to climate change and the ability to contribute to solutions (Lecocq et al., 2022). Both international negotiations and the scientific literature have paid ample attention to justice for at least three decades. Justice is, for instance, referred to in several articles of the Paris Agreement, including Article 2.2: 'This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances' (UNFCCC, 2015b). The scientific literature has contributed to make the notion of climate (or energy) justice more concrete, based on, among others, ethical, legal, and efficacy considerations (Ringius et al., 2002; Höhne et al., 2014; Grasso, 2007; Schlosberg & Collins, 2014; UNFCCC, 1992; Zimm et al., 2024; van den Berg et al., 2020; Sovacool & Dworkin, 2015; Jenkins et al., 2016; Rajamani et al., 2021).

However, in the scenario literature, most scenarios do not explicitly focus on issues of international justice (Jafino et al., 2021; Rubiano Rivadeneira & Carton, 2022). Instead, the key focus in recent years has often been on how to meet specific mitigation targets through different reduction strategies and related feasibility questions. Most IAM pathways follow cost-effectiveness approaches, without making any additional equity assumptions. These mitigation pathways implicitly assume that where and how action occurs can be separated from who pays (in other words, countries could, on the basis of fairness criteria, finance mitigation action elsewhere) (IPCC, 2022; Bauer et al., 2020; Den Elzen et al., 2008). The lack of attention to equity has been a subject of critique in the past (Pedersen et al., 2022). And recently, this critique has resurfaced (Kanitkar et al., 2024; Low et al., 2024). Kanitkar et al., for instance, criticise current scenarios for not addressing the issue of justice in allocating the remaining carbon budget, as well as for the underlying assumptions, including those related to income growth. It should be noted that the critique can, to some degree, be countered. For instance, some parts of the literature do address equity issues (see further below), and the growth assumptions in the Shared Socio-Economic Scenarios do show income convergence (Riahi et al., 2017). At the same time, however, the critique has received considerable attention.

An element that does play a role is that key questions for scenario analysis have also changed over time (van Beek et al., 2020). Right after the Paris Agreement, partly in response to the explicit request by the parties of the Agreement (UNFCCC, 2015b), the focus was on the feasibility of the 1.5 °C target and the various ways of achieving it. However, the contribution of different countries to mitigation efforts has now become increasingly important. One reason is that the first Global Stocktake has shown that the current pledges are insufficient to meet the Paris goals (UNFCCC, 2024). A key question is: which parties will have to do more? Evidently, more attention to climate justice will be needed in the coming years.

The importance of considering justice when setting policy targets based on integrated assessment scenarios has recently been highlighted by the recommendation of the European Scientific Advisory Board on Climate Change (ESABCC). As part of the legislative process to move forward with climate policies in the EU, the ESABCC was charged with identifying GHG emissions targets for the EU beyond 2030. In their recent report, they recommend keeping the EU's greenhouse gas emissions budget within a limit of 11 to 14 $GtCO_2e$ between 2030 and 2050 (ESABCC, 2023). Staying within this budget requires deep and rapid emission reductions of 90–95% by 2040, relative to 1990. To arrive at

these recommendations, the ESABCC selected a target range corresponding to more ambitious IAM pathways since that would improve the fairness of the EU's contribution. Fairness considerations further suggest that the EU's ambitious domestic emission reductions need to be complemented by measures outside the EU to achieve a fair contribution to climate change mitigation. Further work is therefore needed to include justice considerations in the assessment and development of IAM scenarios, which would enable and facilitate policy choices compatible with diverse ethical principles and value systems.

Here, we argue that at least the following issues will need to be addressed more in the future than has been done in recent years: (1) the contribution of different parties to the Paris Agreement, (2) the evaluation of overall economic impacts for countries, (3) the evaluation of a wider set of scenario assumptions, (4) a focus on poverty reduction and decent living standards, and (5) identifying impacts and protection measures for vulnerable groups within countries.

Finally, it should be noted that the scientific literature could also contribute to the question of what 'justice' means in the context of climate action. Should climate action simply not exacerbate existing inequality and injustice trends or should it lead to an improvement of overall equity and justice (even when unrelated to climate change)? Very different opinions have been expressed on this. Some have argued that issue-linking (aiming for improvement in equity as part of climate policy) can seriously slow down the possibility of finding climate solutions (which could be dangerous as climate change itself tends to hit the poor population harder) (Posner & Weisbach, 2010). On the other hand, issue-linking (as in the Earth justice concept) can also be understood from a holistic SDG perspective. Different ambitions clearly play a role in the current debate on justice.

Contribution of different parties

As shown in the literature, the various justice principles and how they can be interpreted have led to the development of multiple allocation methods in climate policy (Grübler & Fujii, 1991; Den Elzen et al., 2008; Lahn & Sundqvist, 2017; Skeie et al., 2017). This aligns with even earlier language around international bodies having 'common but differentiated responsibility' for emissions reductions (Rajamani, 2002). In the coming years, scenario analysis should increasingly examine possible fair allocations of efforts. This includes exploring various ways to implement allocation, including the use of flexible instruments ranging from domestic implementation to full use of flexible mechanisms (as mentioned under Article 6 (UNFCCC, 2015b)). Key fairness criteria include equality, capability, and responsibility. There are various ways to implement such targets, including resource sharing and effort sharing, as well as focusing on carbon debt. Claiming, however, that this can be addressed as an ex-post evaluation only, will not be enough as it implicitly assumes that countries are willing to fully finance mitigation elsewhere. Even if this might be economically attractive, there can be several burdens attached to this. If there is no full financing, an equitable outcome can only be achieved by a larger differentiation of domestic mitigation efforts closer to regional fair shares (Bauer et al., 2020). This can have strong implications for scenario results and their feasibility.

Evaluation of overall economic impacts

The implementation of climate policy leads to various impacts, including the direct costs of implementing climate measures, impacts on trade and technology development, and (remaining) effects of climate policy and air pollution. On the other hand, their implementation also produces benefits in terms of avoided climate impacts which have been shown to disproportionally affect poorer households (Gilli et al., 2024). It will be important to analyse the different ways of implementing climate policy from a broad macroeconomic perspective, to ensure fairness, particularly for countries vulnerable to climate impacts. For instance, De Cian et al. (2016) have shown how accounting for climate impacts could significantly change fairness views based on mitigation alone. Some studies have shown that inequality is consistently reduced in 1.5 °C – 2 °C mitigation pathways from a combination of redistributive policies using carbon pricing

revenues and the avoided increase in inequality from climate damages (Emmerling et al., 2024).

Evaluation of a wider set of scenario assumptions

Scenarios include a range of assumptions that are related to equity. This includes economic convergence, but also, for instance, discount rates, assumptions on costs of capital, and even completely new narratives on degrowth. The SSPs cover a wide range of assumptions regarding future income convergence (Riahi et al., 2017). These scenarios are based on ranges deemed feasible by the demographic and economic teams involved. However, it should be noted that current income differences are vast. As noted by Kanitkar et al. (2024), even in scenarios with considerably higher income growth in developing countries than in developed countries, the absolute income differences remain similar to what they are now (or even grow larger in some cases). Given that several developing countries have indicated they aim for higher growth rates, it will be important to explore the impacts of a wider set of economic assumptions, including higher convergence rates and degrowth scenarios. Recent studies explored a range of sustainable development pathways following different narratives including rapid economic convergence and a strong reduction of relative income inequalities within regions (Soergel et al., 2024; Min et al., 2024). This might also involve better communication with the various parties involved in international climate policy on this issue as well as a better communication of the key assumptions.

Reduction of poverty and achievement of decent living standards

As part of the Sustainable Development Goals, the world has promised to eradicate poverty (UN, 2015). Unfortunately, however, progress has been very limited so far. A key question is how this goal can be achieved. It will be important to explore different pathways to do so. One concept that can be used is the DLS (Decent Living Standards) approach, which aims to achieve decent lives along multiple dimensions (Rao & Min, 2018). Several papers have explored the achievement of DLS in terms of energy use (Kikstra et al., 2021), but further investigation into this will be a critical justice issue in the coming years.

Impacts and protection of vulnerable groups

Climate mitigation and climate change may impact specific groups within countries in different ways. For instance, workers in fossil fuel industries or poor people in certain countries might be more affected by climate policy than others. For instance, modelling in Europe has shown that a transition to climate neutrality may increase modest inequality across income classes, with low-income households facing the most negative effects (Fragkos et al., 2021). However, using carbon tax revenues as lump-sum transfers to support household income and as reduced social security contributions, will increase employment and reduce income inequality across households in EU countries. Another example incudes indigenous peoples who are excessively dependent on natural resources, forests, and land use activities, which are greatly impacted by climate change (Ford et al., 2020). It will become increasingly important to identify such unequal outcomes of climate policy and determine how to mitigate these impacts. This may, in some cases, have consequences for the mitigation scenarios themselves (e.g. influencing the speed at which they can be implemented).

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Annex 1: List of Net-Zero Targets per Country

Based on Net Zero Tracker (2024)

Country Name	Net-Zero Target	Status of Net-Zero Target	Coverage of Net-Zero Target	Has Plan
Afghanistan	Net zero	Proposed	Not Specified	No
Albania	No target	No target	No target	Yes
Algeria	No target	No target	No target	Yes
Andorra	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Angola	Net zero	Proposed	CO_2 only	No
Antigua and Barbuda	Net zero	In policy	CO_2 and other GHGs	No
Argentina	Net zero	In policy	CO_2 and other GHGs	No
Armenia	Climate neutral	Pledge	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	Yes
Bahrain	Net zero	Pledge	Not Specified	No
Bangladesh	Net zero	Proposed	CO_2 and other GHGs	No
Barbados	Carbon neutral(ity)	Pledge	CO_2 and other GHGs	Yes
Belarus	No target	No target	No target	Yes
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	Yes
Bermuda	No target	No target	No target	No
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	Yes
Botswana	No target	No target	No target	Yes
Brazil	Carbon neutral(ity)	In policy	Not Specified	No
Brunei Darussalam	No target	No target	No target	Yes
Bulgaria	Climate neutral	Pledge	Not Specified	No
Burkina Faso	Net zero	Proposed	Not Specified	No
Burundi	Net zero	Proposed	CO_2 and other GHGs	Yes
Cambodia	Carbon neutral(ity)	In policy	Not Specified	Yes
Cameroon	No target	No target	No target	Yes
Canada	Net zero	In law	CO_2 and other GHGs	Yes
Cape Verde	Net zero	In policy	Not Specified	No
Cayman Islands	No target	No target	No target	Yes
Central African Republic	Net zero	Proposed	CO_2 and other GHGs	Yes
Chad	Net zero	Proposed	CO_2 and other GHGs	Yes
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	Achieved	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	Yes
Croatia	Climate neutral	In policy	CO_2 and other GHGs	Yes
Cuba	No target	No target	No target	Yes
Cyprus	Climate neutral	In policy	CO_2 and other GHGs	Yes
Czech Republic	No target	No target	No target	No
Dem. Rep. Congo	Net zero	Proposed	CO_2 only	No
Denmark	Net zero	Pledge	CO_2 and other GHGs	Yes
Djibouti	Net zero	Proposed	CO_2 only	No
Dominica	Carbon neutral(ity)	In policy	CO_2 only	No
Dominican Republic	Net zero	In policy	CO_2 and other GHGs	No
Ecuador	Net zero	Proposed	Not Specified	No
Egypt	No target	No target	No target	Yes
El Salvador	No target	No target	No target	Yes
Equatorial Guinea	No target	No target	No target	Yes
Eritrea	Net zero	Proposed	CO_2 and other GHGs	Yes
Estonia	Zero emissions	Pledge	CO_2 and other GHGs	Yes
Eswatini	No target	No target	No target	Yes
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	Net zero	In law	CO_2 and other GHGs	Yes
Gabon	Carbon neutral(ity)	Achieved	CO_2 and other GHGs	No
Georgia	Climate neutral	In policy	CO_2 and other GHGs	Yes
Germany	Climate neutral	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	Net zero	Proposed	CO_2 and other GHGs	Yes
Guatemala	No target	No target	No target	Yes
Guinea	Net zero	Proposed	CO_2 and other GHGs	Yes
Guinea-Bissau	Net zero	Proposed	CO_2 and other GHGs	No
Guyana	Net zero	Achieved	Not Specified	No
Haiti	Net zero	Proposed	Not Specified	No
Honduras	No target	No target	No target	Yes
Hungary	Net zero	In law	Not Specified	No
Iceland	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
India	Net zero	In policy	Not Specified	No
Indonesia	Net zero	In policy	CO_2 and other GHGs	Yes
Iran, Islamic Republic of	No target	No target	No target	Yes
Iraq	No target	No target	No target	Yes
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	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Jamaica	Net zero	Pledge	Not Specified	No
Japan	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Jordan	No target	No target	No target	Yes
Kazakhstan	Carbon neutral(ity)	In law	CO_2 and other GHGs	Yes
Kenya	No target	No target	No target	Yes
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	Proposed	Not Specified	No
Lesotho	Net zero	Proposed	CO_2 only	No
Liberia	Net zero	In policy	Not Specified	No
Libya	No target	No target	No target	
Liechtenstein	No target	No target	No target	No
Lithuania	Net zero	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	Yes
Madagascar	Net zero	Proposed	CO_2 and other GHGs	Yes
Malawi	Net zero	Proposed	Not Specified	Yes
Malaysia	Net zero	In policy	CO_2 and other GHGs	Yes
Maldives	Net zero	In law	CO_2 and other GHGs	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	No
Mauritius	Net zero	Proposed	Not Specified	No
Mexico	No target	No target	No target	No
Micronesia	Net zero	Pledge	Not Specified	No
Moldova, Republic of	No target	No target	No target	Yes
Monaco	Carbon neutral(ity)	In policy	CO_2 and other GHGs	Yes
Mongolia	No target	No target	No target	Yes
Montenegro	Climate neutral	Proposed	CO_2 and other GHGs	No
Morocco	No target	No target	No target	Yes
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 and other GHGs	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	Proposed	Not Specified	No
North Korea	No target	No target	No target	No
Norway	No target	No target	No target	Yes
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	Yes
Panama	Net zero	In policy	CO_2 and other GHGs	Yes
Papua New Guinea	Net zero	In policy	CO_2 and other GHGs	Yes
Paraguay	No target	No target	No target	Yes
Peru	Net zero	In policy	CO_2 and other GHGs	No
Philippines	No target	No target	No target	Yes
Poland	No target	No target	No target	Yes
Portugal	Carbon neutral(ity)	In law	Not Specified	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 policy	CO_2 and other GHGs	Yes
Rwanda	Net zero	In policy	Not Specified	No
Saint Kitts and Nevis	Net zero	Proposed	CO_2 only	No
Saint Lucia	No target	No target	No target	Yes
Saint Vincent and the Grenadines	Net zero	Proposed	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	Proposed	CO_2 and other GHGs	Yes
Saudi Arabia	Net zero	In policy	CO_2 and other GHGs	No
Senegal	Net zero	Proposed	CO_2 and other GHGs	Yes
Serbia	No target	No target	No target	Yes
Seychelles	Net zero	Proposed	CO_2 and other GHGs	Yes
Sierra Leone	Net zero	Proposed	CO_2 and other GHGs	Yes
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	Net zero	Proposed	CO_2 and other GHGs	Yes
South Africa	Net zero	Pledge	CO_2 and other GHGs	Yes
South Korea	Net zero	In law	CO_2 and other GHGs	Yes
South Sudan	Net zero	Proposed	Not Specified	Yes

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)	Pledge	CO_2 and other GHGs	Yes
Sudan	Net zero	Proposed	CO_2 and other GHGs	No
Suriname	Net zero	Achieved	CO_2 only	No
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	
Tajikistan	No target	No target	No target	Yes
Tanzania	Net zero	Proposed	CO_2 only	Yes
Thailand	Net zero	In policy	CO_2 and other GHGs	No
The Bahamas	No target	No target	No target	Yes
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	Net zero	Proposed	CO_2 only	Yes
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	Yes
Tuvalu	Net zero	In policy	CO_2 and other GHGs	Yes
Uganda	Net zero	Proposed	CO_2 only	Yes
Ukraine	Carbon neutral(ity)	In policy	CO_2 and other GHGs	No
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	Net zero	In policy	CO_2 and other GHGs	Yes
Uruguay	Net zero	In policy	CO_2 and other GHGs	Yes
Uzbekistan	No target	No target	No target	Yes
Vanuatu	Net zero	In policy	CO_2 and other GHGs	Yes
Venezuela, Bolivarian Republic of	No target	No target	No target	Yes
Vietnam	Net zero	In policy	CO_2 and other GHGs	Yes
Yemen	Net zero	Proposed	CO_2 and other GHGs	Yes
Zambia	Net zero	Proposed	CO_2 and other GHGs	Yes
Zimbabwe	No target	No target	No target	No

Sharing the Effort — Annual Net-Zero Report 2024

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Disclaimer

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