REPORT

NEW CLIMATE INSTITUTE

# THE BRIDGE TO NET ZERO MATTERS MORE THAN THE DESTINATION

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# THE BRIDGE TO NET ZERO MATTERS MORE THAN THE DESTINATION


**Authors**

| | |
|---|---|
| Leonardo Nascimento | NewClimate Institute |
| Michel den Elzen | PBL Netherlands Environmental Assessment Agency |
| Takeshi Kuramochi | NewClimate Institute |
| Niklas Höhne | NewClimate Institute |

**Design**

| | |
|---|---|
| Polina Korneeva | NewClimate Institute |

**Editing**

| | |
|---|---|
| Hyunju (Laeticia) Ock | NewClimate Institute |

**Communications**

| | |
|---|---|
| Victoria Fischdick | NewClimate Institute |



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**Disclaimer**

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PBL Netherlands Environmental Assessment Agency

# SUMMARY

Acknowledging that the world must reach net-zero greenhouse gas emissions to limit climate change, countries started to set their own national net-zero targets. While net-zero targets set the long-term ambition, countries' mid-term targets, as presented in their Nationally Determined Contributions (NDCs) towards 2030, and short-term policies form a bridge connecting the current state of the world with a net-zero future.

Assessing the interplay between short- and long-term emissions is especially difficult because of different expectations on carbon dioxide removal (CDR) — approaches to remove emissions from the atmosphere. However, to limit climate change, countries need to reduce their actual emissions (independently of CDR) as fast as possible. Therefore, it remains fundamental to understand the magnitude and uncertainty of the actual emissions that remain once countries reach their net-zero targets and to explore means to compare those with short-term actions.

In this study, we expand estimates of the emissions that 20 countries plan to compensate with removals in the year of their net-zero targets to understand how much countries plan to actually reduce emissions. We also develop emission projections up to 2030 under current policies and NDC scenarios to compare those with the remaining emissions estimated for net-zero targets.

We found that current net-zero targets result in substantial and uncertain emissions in the net-zero target year — net zero is clearly not at all zero. We found that remaining emissions associated with net-zero targets reach, on average, 21% of 2019 emissions — ranging between 6% and 59%. Residual emissions from these 20 countries result in at least between 3.4 $GtCO_2e$ and 12.6 $GtCO_2e$ in the net-zero target year, this corresponds to approximately 9–33% of global emissions in 2019. These countries represent approximately 80% of global emissions. If the other countries reduce emissions similarly, this will represent a lower bound of emissions and the associated need for CDR.

We also found that current policies and NDC targets remain woefully misaligned with countries' net-zero targets, even when the uncertainty of these residual emissions is considered. Between 2019 and 2030, emissions under current policies decrease at a pace of -0.2% per year — based on a simple average between countries. If countries meet their NDCs for 2030, emissions would on average decline at -0.7% per year, although the variance among NDCs is much higher. Net-zero targets imply

an average annual change rate of -3.8% per year between 2030 and the net-zero target year. Therefore, countries must reduce their emissions much faster than projected based on their policies and NDC targets.

Despite substantial uncertainty, net-zero targets have helped translate global goals of peaking and declining emissions to the national level. Improving the credibility of net-zero targets and developing additional modelling exercises to support understanding the scale of the sectoral transformations needed remains important. However, more critical to advancing progress towards net zero, is setting out the implementation plan through enhanced policies. To design the policies that will enable emissions reductions in line with net-zero targets, the next round of NDC updates presents an opportunity for countries to carefully consider the interplay between long-term and mid-term targets. At the same time, countries should set adequate short-term actions based on robust evidence to bridge the gap between current policies and their own net-zero targets.

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# /\ 01 INTRODUCTION

Scientific and political consensus show that the world must promptly reduce and reach net-zero greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC) established that reaching and sustaining net-zero global anthropogenic emissions is essential to halt global warming (IPCC, 2023). Parties to the Paris Agreement also committed to collectively achieving a balance between emissions and removals of greenhouse gases in the second half of this century (UNFCCC, 2015).

In recent years, countries started to set their own net-zero targets to bring these global goals into their national contexts (Höhne et al., 2021). They committed to peak and decrease their net greenhouse gas emissions to zero at different dates to reflect their respective capabilities and responsibilities. As of December 2023, around 145 countries, which cover approximately 90% of global emissions, have set or are considering net-zero targets (Climate Action Tracker, 2023). These targets vary in scope and credibility but, if fully implemented, increase the chances of keeping end-of-century warming below 2°C (Rogelj et al., 2023).

Net-zero targets do not exist in isolation; they were adopted in the context of existing national efforts to limit climate change. Countries set mid-term 2030 emission targets in their Nationally Determined Contributions (NDCs) to the Paris Agreement (Nascimento et al., 2023). They also adopt and implement several policies projected to reduce national greenhouse gas emissions (Nascimento and Höhne, 2023). However, both NDCs and current policies are collectively insufficient to reach net zero globally (UNEP, 2024). Full implementation of NDC targets would only reduce global emissions by 4–10% below 2019 levels (UNFCCC, 2021; UNEP, 2024) and fully implementing current policies would merely stabilise global emissions by 2030 (den Elzen et al., 2022; UNEP, 2024).

Although these global trends are clear, analyses comparing NDCs and adopted policies to net-zero targets at the national level are available for only major emitting economies and based on a limited number of modelling approaches (Keramidas et al., 2022; Dafnomilis, den Elzen and van Vuuren, 2023). Lack of comparable of evidence at the national level hinders early course corrections in climate action and limits efforts to design mid-term targets and policies aligned with long-term net zero.

# OBJECTIVES OF THIS STUDY

In our study, we provide evidence that supports the alignment of shorter-term climate actions, such as current policies and NDCs, to longer-term, net-zero targets. We estimate greenhouse gas emissions under different climate action scenarios for different countries to compare and contextualise mitigation efforts implied by countries' net-zero targets. Specifically, we compare emissions under these scenarios to identify whether they imply similar rates of change over time.

However, comparing different climate action scenarios is especially difficult because of varied carbon dioxide removal (CDR). In the short term scenarios, the level of CDR is mostly related to countries' current land-use emission sinks, often quantified and communicated in national inventories (Grassi et al., 2022; Forsell, Gutierrez and Chen, 2024). However, CDR in long-term scenarios often combines technological options[1], such as direct air capture or bioenergy with carbon capture and storage, and natural options , such as afforestation and soil carbon sequestration (Strefler et al., 2021). Many concerns regarding the permanence and feasibility of these long-term CDR options remain (Grant et al., 2021). Mixing short- and long-term scenarios may hide important risks associated with CDR assumptions.

In our analysis, we make the uncertainty regarding CDR more explicit by splitting it from emissions excluding CDR. In the net-zero target year, emissions excluding CDR is equivalent to the 'residual emissions', which has been frequently used in the discussion of net-zero targets (Buck et al., 2022; Smith, Vaughan and Forster, 2024). We use this term when we refer to the remaining emissions under net-zero targets. However, residual emissions are conceptually associated with emissions that remain once countries pursue deep mitigation efforts, which is not the case under the other scenarios analysed. We, therefore, we use the terms emissions excluding CDR, remaining emissions or simply emissions when we refer to remaining emissions under the NDC and current policy scenarios.

We provide two main contributions. First, we expand estimates of emissions excluding CDR to include diverse analyses that inform net-zero targets. This helps explore the different interpretations of the net-zero target in terms of actual emission reductions. Second, we develop emissions projections up to 2030 under current policies and NDC scenarios and compare those to the remaining emissions estimated for net-zero targets.

1 In this analysis, we focus on the natural sinks and sources as defined in the national inventories and aligned with the IPCC guidelines. For example, our estimates exclude emissions sources and sinks from unmanaged land.

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# DATA AND METHODS

First, we estimate a range of net-zero residual emissions for 20 countries based on (i) official sources, such as long-term strategies, (ii) third-party modelling exercises, such as scientific and other modelling studies, and (iii) our own assumptions *(→ Fig. 1)*. These estimates constitute the basis for our net-zero scenario. Second, we develop NDC and current policy scenarios for these countries and compare the emissions excluding CDR in these scenarios to the estimated residual emissions associated with net-zero targets.

Whenever possible, the current policy scenario is based on multi-model estimates of the effect of policies in force as of June 2024. The NDC scenario is based on the targets submitted to the UNFCCC as of October 2024. Due to differences in the period covered by each scenario, we calculate the average annual emission change rate associated with each scenario to compare them.

In our analysis, emissions refer to emissions sources that remain and must be balanced by emissions sinks. All emissions are presented in Global Warming Potentials (GWP-100) of the IPCC's fourth assessment report (AR4). Whenever the information was unavailable, we assumed no conversion was necessary. All historical emissions are aligned with countries' official inventories submitted to the UNFCCC.

## A BRIEF DISCUSSION ON RESIDUAL EMISSIONS

Residual emissions is the common term used when referring to the positive portion of net zero (Lamb, 2024). It is often used in analysis that explore long-term strategies or net-zero targets. Some studies analysed long-term strategy documents and found that the levels of residual emissions are often not well defined nor quantified in these documents (Buck et al., 2022). This increases the uncertainty regarding their magnitude, origin and the implied need for CDR (Buck et al., 2022; Smith, Vaughan and Forster, 2022). In some cases, residual emissions may originate where they are hard to eliminate, such as when associated with enteric fermentation or cement production. In other cases, they may result from an unwillingness to reduce emissions that can plausibly be compensated by sinks or through international carbon credits. Some assumptions about hard-to-eliminate emissions are context-driven and subject to change as the political and technological landscape evolve (Buck et al., 2022).

Comparing these long-term residual emissions to countries' short-term emissions requires an equivalent scope. Scenarios must account for all emissions sources and exclude CDR. In our study, we decided against using the term 'residual emissions' in the short term, because short-term emissions excluding CDR are conceptually very different from net-zero residual emissions since they, for example, do not

relate to hard-to-eliminate emissions. We encourage others to explore more suited terminology to facilitate like-with-like comparisons between net-zero residual emissions with remaining emissions under different, and specially, short-term scenarios.

Our approach to compare different scenarios is quantifying and comparing the level of remaining emissions. This approach clarifies emission source reductions expected in net-zero targets and the magnitude of CDR required to balance out remaining emissions. For scenarios covering the period up to 2030, we assume that remaining emissions are equivalent to countries' emissions excluding land use sinks. We based our analysis of land use sinks on countries inventories (Grassi et al., 2022; Forsell, Gutierrez and Chen, 2024) and studies that project countries' land-use emission sinks based on current policies (Nascimento et al., 2024). In scenarios compatible with net-zero targets, different CDR options need to be considered. We rely on the information presented in the modelling exercises to estimate residual emissions (see more on 'Estimating net-zero residual emissions'). To estimate residual emissions, we also consider all relevant emissions, not only those covered by the net-zero target.

## ESTIMATING NET-ZERO RESIDUAL EMISSIONS

We estimate the level of absolute residual emissions based on three main approaches: official estimates, third-party estimates, and our own assumptions. For the first two approaches, we rely on existing economy-wide studies that model pathways towards the net-zero target year. We also consider scenarios that reach net zero slightly before or after the target year. However, we exclude modelling exercises that only cover a subset of the national emissions, such as the energy sector, or scenarios that result in increasing emissions from today's levels coupled with a high projected increase in emission sinks.

Official estimates are mostly based on documents submitted to the UNFCCC (e.g., the United States' long-term strategy), or their related annexes (e.g., EU methodological document attached to its long-term strategy). In some cases, such as in Australia, the government has not submitted a detailed document to the UNFCCC but provides a detailed report, which we included in our analysis, outlining distinct scenarios to meet its net-zero target.

Third-party estimates are based on publicly available studies that model pathways aligned with the countries' net-zero target. We consider peer-reviewed studies that cover many countries (e.g., Bataille et al., 2020; Dafnomilis et al., 2023) or modelling exercises that explore different scenarios for a single country (Kong et al., 2023). We also consider modelling exercises from authoritative sources. Some of the

studies reviewed include the World Bank Climate and Development report series (World Bank, 2024) and the latest edition of Global Energy and Climate Outlook (Keramidas et al., 2023). Finally, we also consider country-specific studies, such as the Net Zero America report (Larson et al., 2021) for the US and Canada's Net Zero Future report for Canada (Dion et al., 2021). We included studies published before October 2024. We did not intend to conduct a comprehensive literature review of modelling exercises but to illustrate the degree of uncertainty underpinning net-zero targets.

We also prepared our own scenario based on simplified assumptions to complement existing estimates. These estimates are compatible with a deep reduction of emissions covered by net-zero targets and likely underestimate actual remaining emissions. However, they provide a conceptual lower bound estimate for residual emissions in the net-zero target year. We estimated residual emissions using two main approaches.

First, we estimated projected levels of land-use sinks based on the historical average of sinks and the projected sinks based on current policies (Nascimento et al., 2024). We then assume that this will remain constant until the net-zero target year. This assumes that countries will emit as much as their natural sinks allow them to and that the uptake of technological CDR will remain negligible before the net-zero target year. We note that technological CDR is often covered in other modelling exercises and that this assumption would likely result in an underestimation of emission sinks, which translates to a lower level of residual emissions.

Second, we estimated how fast emissions sources can decline from 2030 (the latest year of available emissions under current policies) until the net-zero target year. We assumed that countries with net-zero targets will strive to reach net-zero $CO_2$ emissions but that non-$CO_2$ emissions will likely remain a source of emissions in the net-zero target year (Edelenbosch et al., 2024; Lamb, 2024) . For non-$CO_2$ emissions, our assumption varies depending on whether the net-zero target covers all greenhouse gases or only $CO_2$. When the net-zero target covers all greenhouse gases, we assume that non-$CO_2$ emissions will decline at the rate necessary globally to meet the 1.5°C limit (scenario categories C1 and C2). When the target only covers $CO_2$, we assume that non-$CO_2$ emissions will follow the reference scenario of the US Environmental Protection Agency for those gases (US EPA, 2019). We acknowledge that countries would probably still pursue some mitigation measures independently of whether emissions are covered by the net-zero target. This makes the assumption of a reference scenario for non-$CO_2$ gases unlikely in reality. However, considering the scope of the analysis, which is to quantify the residual emissions implied by current net-zero targets, we maintain that this assumption is justified when countries exclude or are unclear about the inclusion of non-$CO_2$ gases.

## ESTIMATING CURRENT POLICY AND NDC EMISSIONS

The NDC scenario assumes that countries will meet their current NDC targets, as of October 2024. The NDC quantification departs from mapping out key information about the target, such as sectoral coverage, reference for calculation of the emission reductions, especially when presented as a percentage reduction, and conditionality. A detailed description of the method to estimate emissions implied by current NDCs is presented elsewhere (Nascimento et al., 2024).

The current policy scenario is based on the effect of currently adopted policies on greenhouse gas emissions up to 2030. We created a range for emissions based on selected policies. We conducted a careful analysis to define which policies should be included in the quantification for each country. Each selected policy has a set of quantifiable indicators, such as fuel efficiency standards. We use these indicators to estimate the emissions associated with each policy and then subtract that effect from a reference scenario. Whenever available, we combined policy projections prepared using two models[2] that use different methods to estimate the effect of policies (Nascimento et al., 2024).

In our analysis, we assume that the selected policies will be fully implemented. However, diverse economic and political factors will probably affect their implementation. Policies in force may also be dismantled with administration changes. The actual emissions of these countries in 2030 is intrinsically uncertain. This policy scenario constitutes our best available estimate of the effect of policies as of July 2024. All projections are harmonised to official historical emissions based on the country's official greenhouse gas emission inventories.

To ensure CDR is excluded from the projections, we add land-use sinks to the emissions projections to estimate comparable residual emissions across scenarios whenever a country has a land-use sink in its current policy (Nascimento et al., 2024) or NDC scenario (Forsell, Gutierrez and Chen, 2024). For example, if emissions under current policies reach 150 $MtCO_2e$ in 2030 but the country has a 10 $MtCO_2e$ land-use sink, we assume that emissions excluding CDR under current policies will be 160 $MtCO_2e$ in 2030.

## SCENARIO COMPARISON

Since the scenarios cover different periods, we compare them using the average annual emission change rates. The current policy and NDC scenarios cover the period up to 2030 while net-zero targets are all presented for years between 2050 and 2070.

2 Emissions projections (excluding land-use) were calculated using the integrated assessment model IMAGE and a bottom-up model that calculates the impact of policies on country-specific reference scenarios. Land-use emissions projections are calculated by the GLOBIOM land-use model. For further information, see Nascimento et al. (2024).

We estimate the average linear annual emissions change rate necessary to reach the absolute emission level calculated for each scenario. The change rate for the policy scenario is calculated as the average change rate between 2019 and 2030. The same timeframe is used for the NDC scenario. The annual emissions change in the net-zero scenario is calculated between 2030 and the net-zero target year. We assume that after 2030 the country will pursue efforts to meet its net-zero target and that emissions will linearly reach the residual emissions level in the net-zero target year.

In all cases, the change rate is calculated considering the endpoints and the total time in between them, i.e., $r = (E_{final}/ E_{initial} - 1)/(t_{final}-t_{intial})$. For example, if under the current policy scenario emissions change from 100 $MtCO_2e$ in 2021 to 55 $MtCO_2e$ in 2030, the calculated annual average emission change rate is 5%. This approach does not account for the shape of the pathway. This has implications for the carbon budget used by these countries to reach their targets and consequently the collective climate goals of the Paris Agreement. This approach, however, enables a comparison of the average dynamic associated with different scenarios.

This approach also does not aim to imply that countries should linearly decrease their emissions to reach net-zero targets. Global decarbonisation scenarios in line with the 1.5°C goal of the Paris Agreement require early steep emission reductions, which slow down over time when mitigation actions become costlier. Countries that accelerate short-term actions will reduce emission reduction rates later. Alternatively, countries that take longer to act, say by continuing to increase emissions post-2030, will increase the necessary decline rates to meet their own net-zero targets.

## COUNTRY COVERAGE

We selected countries based on diverse criteria. First, they must have a net-zero target. The cut-off date of this analysis was set before Mexico announced its net-zero target. Since we compared the growth rates across different scenarios, the possibility to develop emissions projections based on current policies is part of the selection criteria. As a result, we analyse 20 countries that together account for approximately 80% of global greenhouse gas emissions ***(→ Fig. 1)***.

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# RESULTS

# LACK OF SUPPORTING EVIDENCE UNDERPINNING NET-ZERO TARGETS

We find a striking absence of official modelling exercises supporting net-zero targets ***(→ Fig. 1)***. Eight out of the 20 countries analysed do not disclose any official modelling exercise supporting their net-zero targets. This probably results in a limited understanding or limited discussions regarding the scale of transformation needed to meet these targets and results in delayed climate action, as countries remain unaware of the key short-term steps required to accelerate action and how the emission reduction efforts are distributed across sectors.

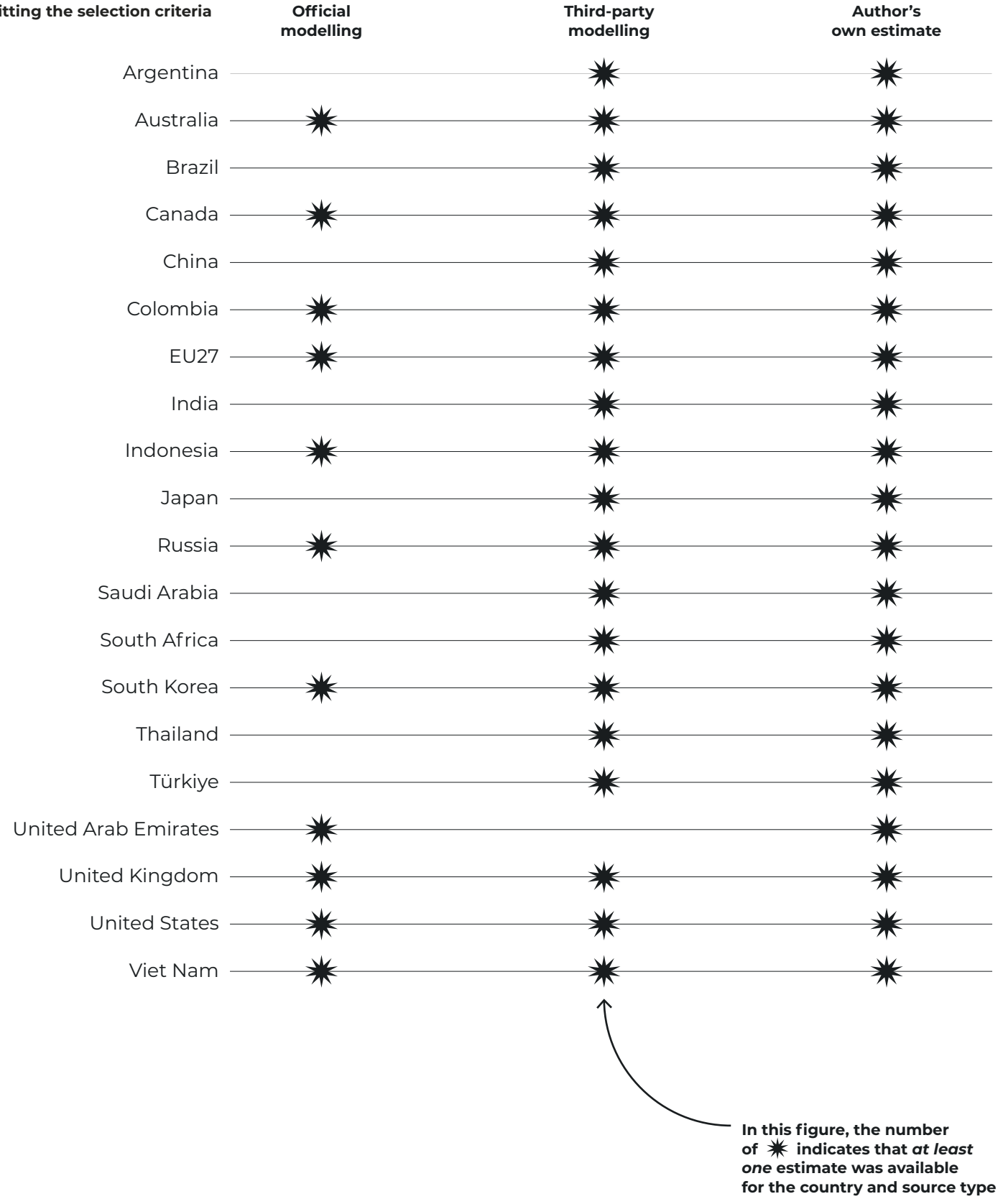
The information provided in official modelling exercises is also insufficient to fully assess the risks and implications of net-zero targets. Even when official scenarios exist, most only communicate land-use-related emissions sinks, and only a few clarify explicit assumptions about technological CDR and international credits — the latter being unavailable for all countries analysed, except for Australia. Evaluating the risks and barriers associated with these scenarios is virtually impossible with the currently available information.

More scenarios were available when we expanded our analysis to consider third-party studies from international organisations, researchers and other service providers that provide analytical evidence of the systemic transformation associated with net-zero targets. In most scenarios available, the power sector decarbonises first and sometimes reaches negative emissions. However, available scenarios lack clarity on the underlying assumptions regarding existing or future technologies. For example, explicit assumptions about bioenergy carbon capture and storage are mostly unavailable. Modelling exercises that reach net-zero in the power or energy sectors are more commonly available (Green and Reyes, 2023). However, net-zero economy-wide exercises, which are important for understanding the implications for other sectors of the economy, are still missing in some countries.

Most existing modelling exercises are also not explicit on the reasoning behind residual emissions. For example, they do not distinguish whether residual emissions are driven by the availably of CDR, such as due to large natural sinks potential, by policy targets or by the lack of mitigation options to fully eliminate emissions across sectors. Although research shows that long-term strategies net-zero targets are mostly driven by policy targets (Buck et al., 2022), third-party modelling exercises often do not clarify the implicit assumptions regarding the origin of these residual emissions.

**Fig. 1**

**List of countries analysed and availability of economy-wide net-zero scenarios fitting the selection criteria**



Also, fewer insights about the net-zero target are available when these targets are further into the future. This is especially relevant in emerging economies, which often have targets for years beyond 2050 and have not yet peaked their emissions. Translating these long-term net-zero targets into intermediate targets is fundamental to ensuring the path to net-zero becomes clearer. The next round of NDC updates, expected to be submitted by 2025, will play an important role in connecting these distinct timeframes.

## NET-ZERO TARGETS STILL RESULT IN SUBSTANTIAL RESIDUAL EMISSIONS

We complemented existing scenarios with our estimates of residual emissions in the net-zero target year (see Methods). We combined all estimates to create a range of uncertainty for these emissions and explore the space of potential interpretations of the emissions reductions implied by current net-zero targets.

We found that residual emissions associated with net-zero targets reach on average 21% — between 6% and 59%. This central estimate for each country is within 5 percentage points of other studies that analysed long-term strategies submitted to the United Nations Framework Convention on Climate Change (Buck et al., 2022; Smith, Vaughan and Forster, 2024). As expected, our values often broaden the uncertainty range since they account for different possibilities of the pathway to net zero.

Many countries with substantial forest cover are among those with the highest share of residual emissions. Our estimate of net-zero residual emissions for Indonesia, Brazil, and Russia shows the land-use sector contributing to substantial emission sinks in the future. Although in Russia, the land-use sector already contributes to net emission sinks, in Brazil and Indonesia, the sector is currently a large source of emissions. Quickly eliminating land-use emissions is paramount to ensure this sector supports balancing residual emissions in the net-zero target year. Relying on substantial land-use emission sinks to balance out emissions sources is a risky strategy to reach net zero considering diverse accounting and permanence issues (Chiquier et al., 2022).

In a few countries, the upper end of residual emissions is caused by the exclusion of non-$CO_2$ gases of the net-zero target. Most notably China's net-zero target only includes carbon dioxide. This results in higher residual emissions, up to 30%, since we assume that non-$CO_2$ emissions will continue on the current trajectory. In 2023, China took steps to expand greenhouse gas coverage to include non-$CO_2$ gases in its climate commitments (Patel, 2023). Such inclusion could substantially reduce

our estimate of aggregated residual emissions. In India, for example, the scope of the net-zero target is unclear. In our own estimate, we conservatively assumed that the target only covers $CO_2$. Expanding coverage of net-zero targets to include non-$CO_2$ gases is a clear means to reduce the estimate of residual emissions in these countries and globally.

We also found that countries themselves tend to estimate higher levels of residual emissions compared to third-party modelling exercises and our own estimates. In twelve of the countries analysed, our range is based on residual emission estimates from official sources, third-party modelling exercises and our own estimates. In most of these twelve cases, our own estimates result in the lower end of the residual emissions range. This is not the case for Thailand, South Korea, and the EU, where third-party modelling exercises result in lower residual emissions. Colombia is the only one of the twelve countries where officially estimated residual emissions are responsible for the lower end of the estimates.

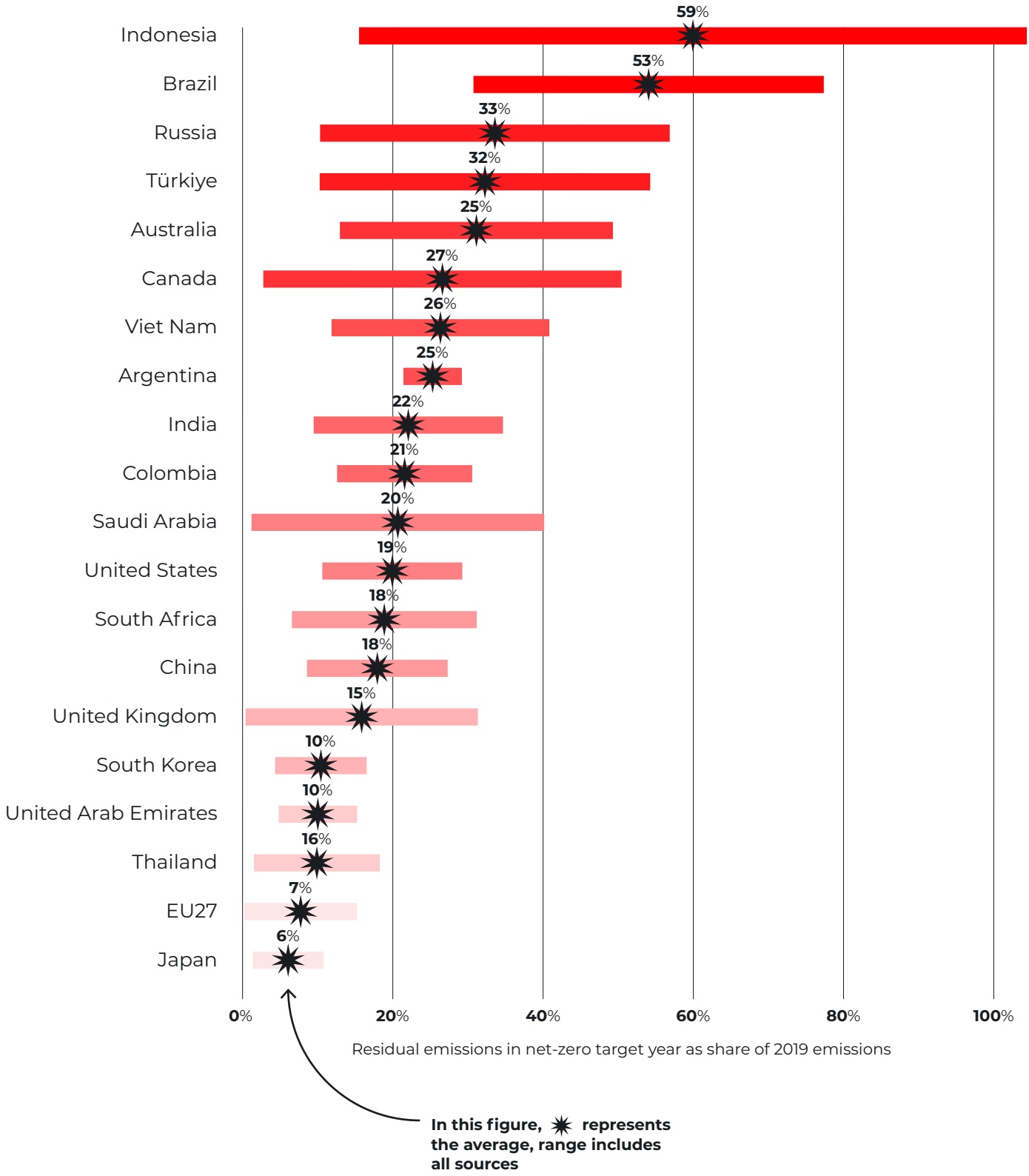
This does not necessarily indicate that countries inflate their residual emissions. In some cases, such as Australia, official modelling exercises clarify the level of international credits used to meet the net-zero target, while third-party modelling exercises focus on the technical possibility of reducing emissions. Non-governmental modelling exercises are often not anchored in national plans and strategic priorities. It is, therefore, expected that third-party modelling exercises and our own estimates would constitute the lower bound of residual emission estimates. Together, these three sources result in a plausible range for residual emissions in the net-zero target year.

In absolute terms, our estimates suggest that up to one-quarter of current global emissions can remain in the net-zero target year. Residual emissions from these 20 countries range between 3.4 $GtCO_2e$ and 12.6 $GtCO_2e$ in the net-zero target year. This corresponds to 9–33% of the analysed countries' emissions and 7–25% of global emissions in 2019. These countries also only represent approximately 80% of global emissions. If other countries reduce emissions similarly, this will represent a lower bound of emissions and the associated need for CDR.

We emphasise that, since countries have different target years, these values cannot be aggregated in one single year. However, since all countries analysed have net-zero target years for 2050 or later, our aggregated emissions represents the lower bound of residual emissions by 2050.

Unsurprisingly, many of today's biggest emitters are projected to reach the highest levels of residual emissions under net-zero targets. China's emissions will probably remain substantial, especially due to the uncertainty regarding actions to mitigate its non-$CO_2$ emissions. Our results show that China's residual emissions can range from 1.2 – 3.7 $GtCO_2e$ in 2060. The United States is the country analysed with the second highest residual emissions, ranging from 0.7 – 1.7 $GtCO_2e$ in 2050. These two

**Fig. 2**
**Level of residual emissions compared to 2019 emissions**



are followed by three other countries with residual emissions that could surpass 1 $GtCO_2e$ in the respective net-zero target years. These countries are Russia (0.2 – 1.2 $GtCO_2e$ in 2060), India (0.3 – 1.1 $GtCO_2e$ in 2070) and Indonesia (0.2 – 1.0 $GtCO_2e$ in 2060).

Estimating residual emissions improves the transparency of net-zero targets and clarifies the need for CDR. Some level of CDR will probably be necessary to reach global net-zero emissions. Illustrative future pathways show that carbon dioxide removal of approximately 15 $GtCO_2e$ (range: 7.2–25 $GtCO_2e$) will be necessary to limit the temperature increase to 1.5°C by the end of the century (Lamb, 2024). However, these scenarios assume that CDR will be coupled with deep emissions reductions. Therefore, prospects of improving emission sinks do not provide a green light for countries to indefinitely maintain or increase emission sources.

## POLICIES ARE WAY OFF TRACK TO MEET NET-ZERO TARGETS

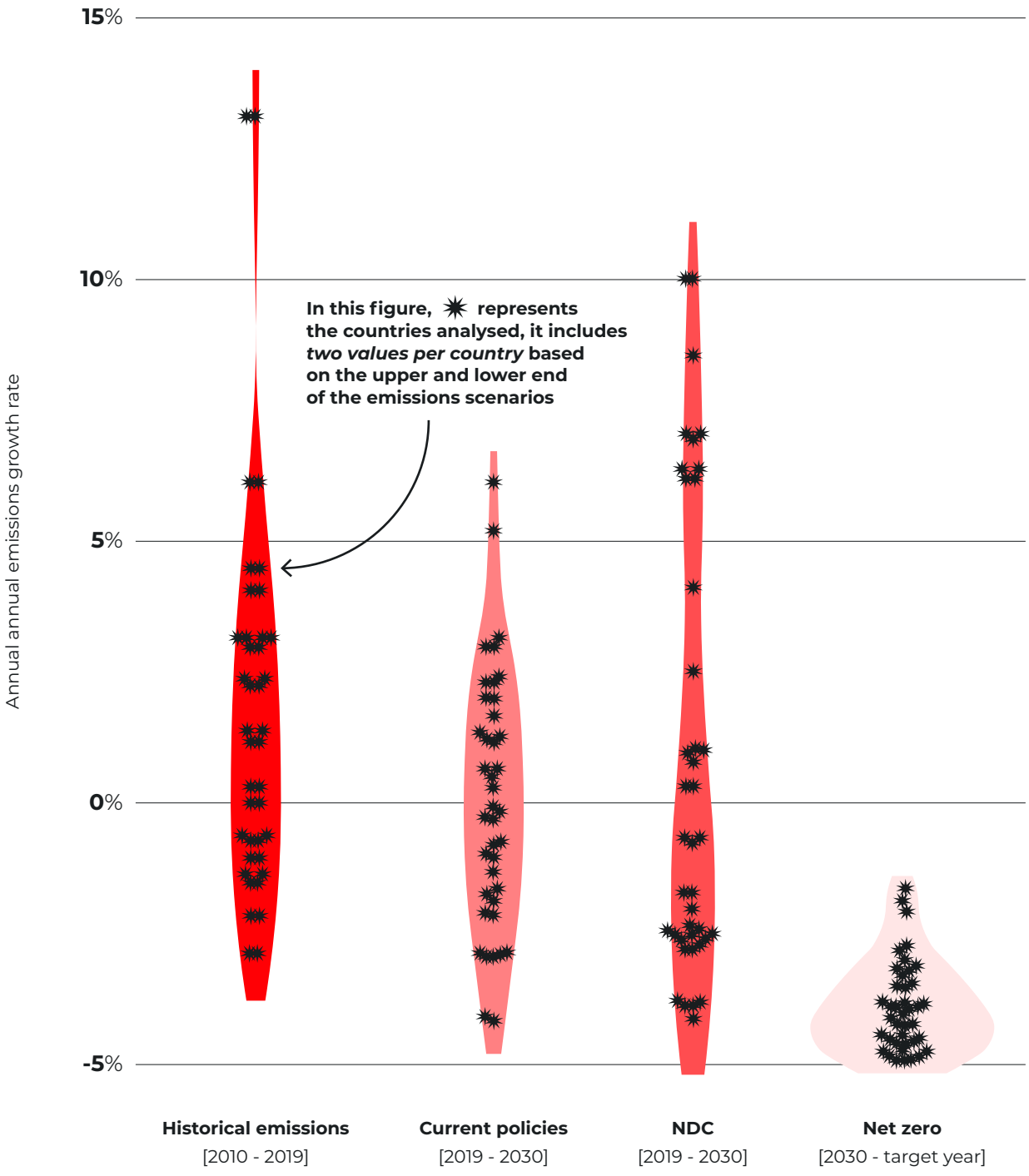
We estimated the level of emissions excluding CDR per country under different scenarios ***(see → Data and methods)***. We then calculated the annual change rate necessary between 2030 and the net-zero target year and compared those to the annual change under different scenarios.

All countries need to accelerate emissions decline to meet their own net-zero targets. Emissions in the countries analysed have grown at an average pace of 1.5% per year between 2010 and 2019 ***(→ Fig. 3)***. This trend is projected to slow down and be slightly reversed before the end of the decade. Between 2019 and 2030, emissions under current policies decrease at a pace of -0.2% per year — based on the average between countries. If countries meet their NDCs for 2030, emissions would on average decline at -0.7% per year, although the variance among NDCs is much higher. Net-zero targets imply an average annual change rate of -3.8% per year between 2030 and the net-zero target year ***(→ Fig. 3)***. Therefore, countries must reduce their emissions much faster than projected based on their policies and NDC targets.

Net-zero targets imply a more coherent level of emissions reduction compared to NDC targets ***(→ Fig. 3)***. Although net-zero targets cover a much longer and uncertain timeframe, they all imply a decline in greenhouse gas emissions post-2030. All countries analysed have committed to declining their emissions at some point after 2030. NDC targets, on the other hand, imply a substantial increase in emissions, in some cases, emissions are even projected to increase faster than based on current policies. Despite uncertainty on the level of residual emissions, net-zero targets offer a clear vision for the trend after 2030.

**Fig. 3**

**Comparison of annual average emission change rate across scenarios — calculated assuming linear change**



Comparing the pathway of individual countries, we found that all countries need to accelerate climate action now if they intend to keep their net-zero promises ***(→ Fig. 4)***. In all cases, emissions must decline at a rate of -4.6% to -2.9% per year after 2030 if countries want to meet their own net-zero targets. Countries with higher net-zero residual emissions are often closer to the rates required under their net-zero targets. This is the case in Australia and the United States, for example. Setting net-zero targets that aim to further reduce emissions implies that these countries would be further off track from the pace needed to meet their net-zero targets. Additionally, under the new Trump presidency, the rate of emissions decline under current policies for the United States will likely be revised upwards in future years.

Although current policy estimates only cover the period up to 2030, any further delay in reducing emissions post-2030 would exacerbate the negative effects of the transition. This delay implies an even faster emissions decline in the future to meet its net-zero targets. In some countries, the transition post-2030 would already be disruptive. For example, in Turkey, India, and Argentina, emissions are projected to grow at more than 2% per year between 2021 and 2030. Such an abrupt transition is unlikely and currently threatens countries' net-zero commitments.

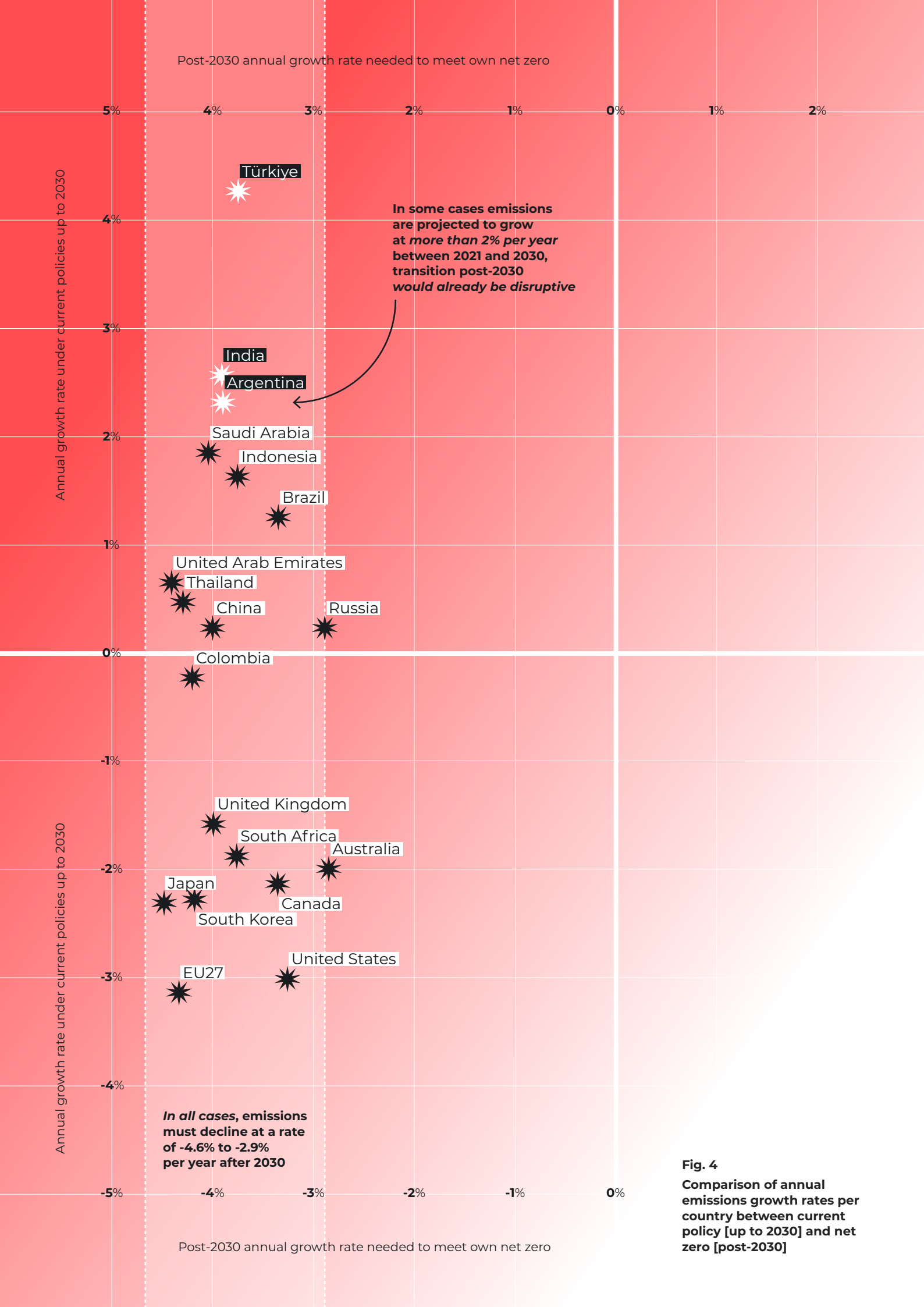



**Fig. 4**

**Comparison of annual emissions growth rates per country between current policy [up to 2030] and net zero [post-2030]**

/ ∧ 04

# IMPLICATIONS

In this study, we quantified countries' residual emissions in the net-zero target year and compared those emissions excluding CDR from current NDCs and policies. First, we found that many countries do not have or communicate official modelling exercises underpinning their targets. Second, we found that current net-zero targets result in substantial and uncertain residual emissions in the net-zero target year. Finally, we found that current policies and NDC targets remain woefully misaligned with countries' net-zero targets, even when the uncertainty of these residual emissions is considered. In this discussion, we outline some of the implications of our findings for the net-zero target debate.

## IMPROVING NET-ZERO TARGETS

Improving the formulation of net zero targets remain relevant. Many net-zero targets still lack important information. In many cases, countries do not clarify whether their targets include all greenhouse gas emissions or the assumptions regarding carbon dioxide removal and international credits. This lack of information contributes to the high level of residual emissions in addition to the already quantified uncertainty in end-of-century temperature increase (Rogelj et al., 2023). As discussed by others, enhancing the formulation of net-zero targets, by clarifying the target emissions scope, reduces some of the uncertainty regarding residual greenhouse gas emissions and the steps necessary for their implementation. It can also help improve the credibility of these targets (Rogelj et al., 2021; Fankhauser et al., 2022).

We also suggest that countries communicate emissions reduction targets separately from their expected sinks or CDR levels. This increases the transparency of the net-zero targets and clarifies the emission source reductions expected by net-zero targets and the magnitude of CDR required to balance out residual emissions.

## UNDERPINNING NET-ZERO TARGETS

Although improving the formulation of net-zero target helps, it is paramount that countries explore the sectoral transformations necessary to reach these them.

Several countries analysed do not disclose modelling exercises underpinning their net-zero targets, which makes it unclear whether they exist. Economy-wide scenarios from third-party sources are also sometimes unavailable or do not transparently outline key assumptions regarding technological CDR deployment. Although estimates of natural emissions sinks are available in the short term,

they vary substantially depending on the modelling exercise and become highly uncertain further into the future. Many scenarios also do not clarify the projected share of different greenhouse gases in emissions projections. This limits the analysis of the role of these gases in meeting the net-zero targets.

Overall, we call for more comprehensive and transparent modelling exercises underpinning national net-zero targets. To inform policymakers, these modelling exercises ideally will explicitly communicate their key assumptions, especially those related to the role of CDR and non-$CO_2$ gases, so that the necessary short-term transformation steps are well understood and can feed into the policymaking process. For example, several of the models analysed assume negative emissions in the power sector, which rely on carbon capture and storage technologies. Understanding the scale of negative emissions required in the power sector, helps planning current investments in power generation technologies and clarifies the magnitude of risks in case these technologies cannot be upscaled at the necessary rate. Failure to implement the building blocks necessary to realise negative emissions in some sectors will make it harder for countries to meet their own net-zero targets.

## CREATING NET-ZERO POLICIES

More importantly, our findings show that current policies are woefully insufficient to put countries on a trajectory to meet their own net-zero targets. Even when we account for residual emissions, all countries must reduce their absolute emissions to meet their own net-zero targets. Countries still need to adopt clear policies to accelerate climate action within the coming decade and reduce the necessary emissions decline rates after 2030.

Although improved modelling exercises inform policymaking, they are insufficient to set out the incentives and policies needed for the societal transformation to reach net zero. Creating net-zero policies will also require additional insights into the politics of net zero, including national-level enablers and constraints (Green and Reyes, 2023). More and more countries are now setting the governance and framework policies aimed at enabling coherent policymaking towards net zero (Averchenkova and Chan, 2023). These framework policies, such as the Fit for 55 package in the European Union or the Framework Act on Carbon Neutrality in South Korea, align policy efforts and create multiple instruments to support net zero. Although it is early to evaluate the effectiveness of these policies, they translate long-term targets into short-term actions covering a wide range of sectors and provide good practice examples of what to consider when translating net-zero targets into policies.

More ambitious targets for the NDCs in 2030 and 2035 would also help bring the long-term ambition of net zero to the present. Using the next round of NDC updates to carefully consider the interplay between long-term and mid-term targets is also fundamental to designing the policies that will enable emissions reductions in line with net-zero targets. Countries preparing their NDC updates in the lead-up to COP 30 in Brazil should not lose sight of the net-zero destination.

Finally, net-zero targets are uncertain in terms of residual emissions, but they have succeeded in translating global goals of peaking and declining emissions to the national level. These targets offer a clearer signpost for countries' climate change mitigation efforts. Although improving the transparency and credibility of net targets would help, setting out the implementation plan through enhanced climate policies is more critical. Countries still need to set adequate short-term actions based on robust evidence to bridge the gap between current policies and their own net-zero targets.

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# ANNEX

## OVERVIEW OF NET-ZERO TARGETS

| Country | Long-term strategy | Net-zero year | Net-zero target scope |
|---|---|---|---|
| **Argentina** | Yes | 2050 | GHG |
| **Australia** | Yes | 2050 | GHG |
| **Brazil** | No | 2050 | Unclear |
| **Canada** | Yes | 2050 | GHG |
| **Colombia** | Yes | 2050 | GHG |
| **China** | Yes | 2060 | $CO_2$ |
| **EU** | Yes | 2050 | GHG |
| **India** | Yes | 2070 | Unclear |
| **Indonesia** | Yes | 2060 | Unclear |
| **Japan** | Yes | 2050 | GHG |
| **Russia** | Yes | 2060 | GHG |
| **Saudi Arabia** | No | 2060 | Unclear |
| **South Africa** | Yes | 2050 | Unclear |
| **South Korea** | Yes | 2050 | Unclear |
| **Thailand** | Yes | 2065 | GHG |
| **Türkiye** | No | 2053 | Unclear |
| **United Arab Emirates** | No | 2050 | GHG, excludes F-gases |
| **United Kingdom** | Yes | 2050 | GHG |
| **USA** | Yes | 2050 | GHG |
| **Viet Nam** | No | 2050 | GHG |

**Note:** Overview based on own research and informed by the Climate Action Tracker (2023).

# NET-ZERO RESIDUAL EMISSION ESTIMATES

| Country | Official min | Official max | Third-party min | Third-party max | Authors min | Authors max |
|---|---|---|---|---|---|---|
| **Argentina** | NA | NA | 70 | 70 | 90 | 100 |
| **Australia** | 200 | 270 | 100 | 140 | 70 | 80 |
| **Brazil** | NA | NA | 550 | 880 | 350 | 580 |
| **Canada** | 120 | 370 | 90 | 280 | 20 | 90 |
| **China** | NA | NA | 1720 | 2180 | 1200 | 3710 |
| **Colombia** | 20 | 50 | 30 | 50 | 50 | 60 |
| **EU** | 490 | 540 | 10 | 450 | 320 | 420 |
| **India** | NA | NA | 1020 | 1080 | 310 | 1110 |
| **Indonesia** | 530 | 840 | 320 | 980 | 150 | 160 |
| **Japan** | NA | NA | 20 | 130 | 60 | 70 |
| **Russia** | 1200 | 1200 | 510 | 1120 | 220 | 430 |
| **Saudi Arabia** | NA | NA | 50 | 50 | 10 | 270 |
| **South Africa** | NA | NA | 60 | 160 | 30 | 140 |
| **South Korea** | 70 | 120 | 30 | 110 | 40 | 40 |
| **Thailand** | 120 | 120 | 10 | 60 | 60 | 70 |
| **Türkiye** | NA | NA | 130 | 280 | 50 | 70 |
| **United Arab Emirates** | 10 | 10 | NA | NA | 10 | 30 |
| **United Kingdom** | 80 | 140 | 50 | 120 | 0 | 50 |
| **USA** | 1130 | 1920 | 950 | 1350 | 710 | 790 |
| **Viet Nam** | 190 | 190 | 90 | 90 | 50 | 70 |

**Note:** Numbers rounded to the nearest 10. For a detailed description of the values, please see 'Methods'.

**NewClimate – Institute for Climate Policy and Global Sustainability gGmbH**

Cologne Office
Waidmarkt 11a
50676 Cologne, Germany

Berlin Office
Schönhauser Allee 10-11
10119 Berlin, Germany

Phone: +49 221 999 83 300
Email: info@newclimate.org
Website: www.newclimate.org