

Closing the gap

THE IMPACT OF G20
CLIMATE COMMITMENTS ON
**LIMITING GLOBAL TEMPERATURE
RISE TO 1.5°C**

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ANALYTICS 



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Table of Contents

1. Executive summary	04
2. Introduction	07
3. Methodology	11
3.1. Scenario definitions	11
3.2. Pathway development and temperature estimates	12
3.2.1. <i>Constructing emissions pathways to 2100</i>	12
3.2.2. <i>Assessment of global warming levels and emissions gaps for each scenario</i>	13
3.3. Net zero targets	13
3.4. 1.5°C aligned 2030 targets	14
3.5. Uncertainties in our analysis	14
4. Results and discussion	15
4.1. Progress in narrowing the gap	16
4.2. Stronger ambition by all G20 members could keep 1.5°C within reach	18
4.3. Closing the G20 ambition gap to 1.5°C	19
4.4. What more needs to be done to keep 1.5°C alive?	21
5. Conclusion: a growing urgency for G20 governments to act	23
6. Appendix	24
7. References	28
8. Endnotes	31

1. Executive summary

Highlights

- The G20—a group collectively accounting for around 75 percent of global greenhouse gas (GHG) emissions, 80 percent of global GDP, and two-thirds of global population—has an outsized role to play in addressing climate change.
- Current submitted nationally determined contributions (NDCs), together with legally binding net zero commitments, put the world on a trajectory to 2.4°C of warming by the end of the century.
- Additional 2030 and net zero pledges that have been announced by the G20 countries but not yet formalised in the NDCs or binding net zero targets could lower projected temperature rise in 2100 to 2.1°C, if fully implemented.
- This is an important step in the right direction but still far from sufficient to meet the Paris Agreement's 1.5°C temperature goal. Moreover, the announced net zero pledges would in most cases require very steep emissions reductions from pledged 2030 levels, which is out of step with feasible pathways identified by global modelling efforts. Ambitious action to rapidly cut emissions in the 2020s is urgently needed to improve the robustness of the pathway to net zero.
- If all G20 members were to adopt mid-century net zero commitments and align their NDCs with a 1.5°C pathway, end-of-century global warming could be limited to 1.7°C.
- With this 0.7°C drop, down from 2.4°C under current commitments, G20 countries could collectively close three-quarters of the temperature gap to 1.5°C, keeping it within reach.
- Those G20 members that have not yet strengthened their NDCs or committed to achieving net zero emissions should do so urgently.
- To ultimately achieve the 1.5°C goal, ambitious action from non-G20 countries is needed too, as well as efforts to curb emissions from international aviation and shipping.
- Achieving ambitious targets will require developed countries to substantially ramp up financial support to developing countries to help reduce emissions and build resilience against climate impacts. G20 developed countries have a particular responsibility to step up their public finance and mobilize private finance for international climate action, to close the gap to the commitment of \$100 billion per year and go beyond.

Context

Under the Paris Agreement, Parties agreed to limit global temperature rise to well below 2°C, and pursue efforts to limit warming to 1.5°C. While some progress has been made in strengthening national climate targets and policies, current national commitments for reducing emissions are still insufficient to meet the Paris Agreement's temperature goal. Strengthened 2030 and mid-century commitments are urgently needed, particularly in the lead-up to COP 26 when countries should submit new or updated NDCs and long-term low GHG emissions development strategies (LT-LEDS). G20 countries have an important role to play in enhancing climate ambition, since this group collectively accounts for around 75 percent of global GHG emissions.

About this paper

This paper presents a set of scenarios that simulate different mitigation commitments made by G20 countries for 2030 and mid-century and the resulting impacts on global temperature rise. The scenarios include a reference scenario from the Climate Action Tracker (CAT) that depicts G20 commitments submitted as of December 2019, before new or updated 2030 emissions targets were expected, two current scenarios depicting restrictive and more inclusive interpretations of current G20 country commitments, and an enhanced ambition scenario depicting strengthened 2030 NDCs and net zero targets for mid-century for all G20 members.

Key findings

Progress has been made towards addressing the Paris Agreement's long-term temperature goal, but there is still a long way to go. The climate pledges that were brought forward by governments in 2015 set the world on track for a temperature increase of around more than 3°C above pre-industrial levels by the year 2100, an extremely dangerous level of warming. By December 2019, CAT estimated that warming based on the NDC targets and policies in place at the time would be 2.8 °C in 2100¹ with temperature rise set to continue into the next century. The NDCs and legally binding net zero targets established since then would lower the estimated global temperature rise to 2.4°C by end of the century if they are implemented in full. This drop in estimated temperature is largely due to strengthened commitments from a relatively small number of G20 governments: Argentina, Canada, the European Union, the United Kingdom, and the United States have submitted enhanced 2030 emissions reduction targets, while Canada, the European Union, Japan, and the United Kingdom have all committed to legally binding net zero emissions targets by 2050. Many vulnerable countries, while contributing a very small share of global GHG emissions, have also shown tremendous leadership in stepping up climate ambition and adopting net zero targets.

Additional actions that have been announced by G20 countries (but not yet formally committed), could further lower estimated end-of-century global temperature rise to 2.1°C if they are fully implemented. Notably, strengthened 2030 emissions reduction targets from China, Japan, and South Africa that have been announced but not yet reflected as NDCs, as well as announced but not legally binding net zero pledges from China and the United States, would make the most sizable contribution to the 0.3°C drop in projected warming levels.

Many G20 countries have yet to announce or submit accelerated emissions reductions. Some of the G20 targets brought forward since December 2019 are only marginally stronger than their previous NDCs, while others repeat existing targets or even weaken their commitments. Australia, Indonesia, Japan, Russia, and South Korea submitted NDCs that are the same as or not meaningfully stronger than their previous NDCs (although South Korea and Japan have announced their intention to revisit this). Brazil and Mexico submitted 2030 targets that are effectively weaker than their previous commitments. China, India, Saudi Arabia, Turkey, and South Africa have not yet submitted new or updated NDCs; and Australia, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa, and Turkey have not formally committed to net zero targets. Collectively, the G20 remains far off track.

Many of the announced net zero pledges by G20 governments will require very steep emissions reductions from pledged 2030 levels. These pledges are out of step with pathways identified by those global modeling efforts that are considered feasible. This puts achieving net zero emissions by mid-century at risk by requiring a very challenging pace of emissions reductions after 2030. Ambitious action to curb emissions in the 2020s through strengthened 2030 NDC emissions-reduction targets is urgently needed to improve the robustness of those net zero pledges.

Current climate commitments by G20 governments still leave a very wide 2030 emissions gap. The difference between the emissions levels that countries have collectively submitted or announced² and the level consistent with limiting warming to 1.5°C in 2030 is 23 GtCO₂e. This wide gap could be reduced by 40 percent if G20 governments with existing net zero targets commit to strengthened 2030 emissions targets aligned with a 1.5°C domestic emissions pathway. If all G20

governments follow suit, the 2030 emissions gap could be narrowed by 64 percent, bringing the world much closer to a 1.5°C trajectory.

If all G20 countries strengthened their 2030 NDCs along a 1.5°C compatible domestic emissions pathway and committed to reach net zero by mid-century, with a faster timeline for developed countries than for developing countries, global temperature rise by 2100 could be limited to 1.7°C. This effort could get us about three-quarters of the way to limiting global warming to 1.5°C, compared with the estimated 2.4°C of warming under current targets.

G20 countries, while crucial, cannot meet the 1.5°C objective on their own. A concerted effort by all Parties over this decade and beyond is required to meet the Paris Agreement's 1.5°C goal. Ambitious action by non-G20 countries will also be needed, as well as curbing emissions from international aviation and shipping. If G20 governments do not strengthen their commitments, other countries would face a near impossible task in making the necessary cuts to keep 1.5°C within reach.

Achieving such ambitious targets will require international cooperation. To achieve full decarbonisation on the timeline necessary for 1.5°C compatibility, many developing countries will need financial support to deliver the necessary pace of emissions reductions. This will require an adequate provision of international finance and support from those countries with the greatest responsibility and capacity for addressing climate change to those that need it. Wealthy nations need to take seriously their commitment under the United Nations Framework Convention on Climate Change (UNFCCC) to mobilise \$100 billion annually (at minimum) and deliver the trillions of dollars required to mobilise climate action by developing countries.



Conclusion

The scenarios developed in this paper underscore the urgency of strengthened commitments to tackle climate change and keep the 1.5°C temperature limit within reach. G20 members have a particularly important role to play, but neither their commitments to rein in emissions by 2030 nor their net zero targets for mid-century yet measure up to what is needed. Further delaying action will result in worsening impacts of climate change in the coming years, escalating the already devastating climate-related floods, wildfires, droughts, and extreme heat incidents already being seen around the world. Delayed action would also result in more costly and challenging rates of decarbonisation in later years, which could eventually become unfeasible.

2. Introduction

In December 2015, 196 Parties to the UNFCCC agreed on a common set of goals to curb global GHG emissions and to accelerate and intensify the actions and investments needed for a sustainable low-carbon future (UNFCCC 2021a). Under the landmark Paris Agreement, Parties agreed to keep global temperature rise to well below 2°C above pre-industrial levels and to pursue efforts to limit the rise to 1.5°C, while increasing resilience to the impacts of climate change and ensuring that finance flows are consistent with a pathway towards low GHG emissions and climate-resilient development.

To advance these objectives, the Paris Agreement requires that all Parties submit 'nationally determined contributions' (NDCs), which are near-term plans that communicate actions that the Party will take to reduce its GHG emissions. Additionally, the Paris Agreement invites Parties to communicate LT-LEDS that will guide countries' transitions to a low-carbon, climate-resilient future by mid-century.

In the first round of NDC submissions, commitments put forward by Parties to the Paris Agreement fell far short of what is needed to keep warming levels well below 2°C, let alone limiting it to 1.5°C. According to the IPCC Special Report on 1.5°C, the first round of NDC commitments would have led to over 3°C of global temperature rise above pre-industrial levels by the end of the century, thus drastically missing the temperature goal set out in Paris (IPCC 2018). To have a good chance of limiting warming to 1.5°C, global GHG emissions in 2030 would need to be 55 percent lower than estimated under the initial round of NDCs, with CO₂ emissions on track to reach net zero by mid-century (UNEP 2019).

Recognising the gap between where GHG emissions are headed and where they need to be to limit dangerous levels of warming, the Paris Agreement introduced a five-year cycle process in which countries are expected to submit more ambitious climate commitments every five years. The first of these five-year cycles is currently under way, with the expectation that countries would submit new or updated NDCs ahead of the UN Climate Change Conference of the Parties (COP 26) in Glasgow in November 2021.

The window for getting emissions on track is closing and the lead-up to the upcoming COP 26 climate summit marks a crucial moment. The governments constituting the G20³—representing more than 80 percent of world GDP and collectively accounting for around 75 percent of global GHG emissions—have a central role to play in delivering stronger climate action and leading the transition that is required to limit temperature rise in line with the Paris Agreement. As both major economic actors and major emitters, the G20 countries need to urgently commit to increasing ambition through strengthened near-term and mid-century targets. Analyses suggest that doing so would contribute not only to limiting warming to 1.5°C, but also to shared prosperity and economic stability globally. Benefits would likely include more jobs, increased energy access, access to sustainable transport, and health improvements (New Climate Economy and WRI 2018).

Some G20 countries have already submitted new or updated NDCs with strengthened 2030 emissions reduction targets and/or committed to reaching net zero emissions by 2050 or 2060 (Figure 1), but further action is still required. Among the G20 members, Argentina, Canada, the European Union, the United Kingdom, and the United States have all put forward enhanced 2030 emissions reduction targets as part of their new or updated NDCs. Australia, Brazil, Indonesia, Japan, Mexico, Russia, and South Korea submitted new or updated NDCs that are the same or not meaningfully stronger than their previous NDCs (although South Korea has announced its intention to revisit this while Japan announced an enhanced 2030 pledge but is yet to formally communicate it). China, India, Saudi Arabia, South Africa, and Turkey have not yet submitted new or updated NDCs at all.

When it comes to net zero emissions targets, Argentina, Brazil, Canada, the European Union, Japan, South Korea, the United Kingdom and the United State all have net zero emissions targets⁴ by 2050, while China has committed to reaching net zero emissions before 2060. Meanwhile, Australia, India, Mexico, Russia, Saudi Arabia, and Turkey have not

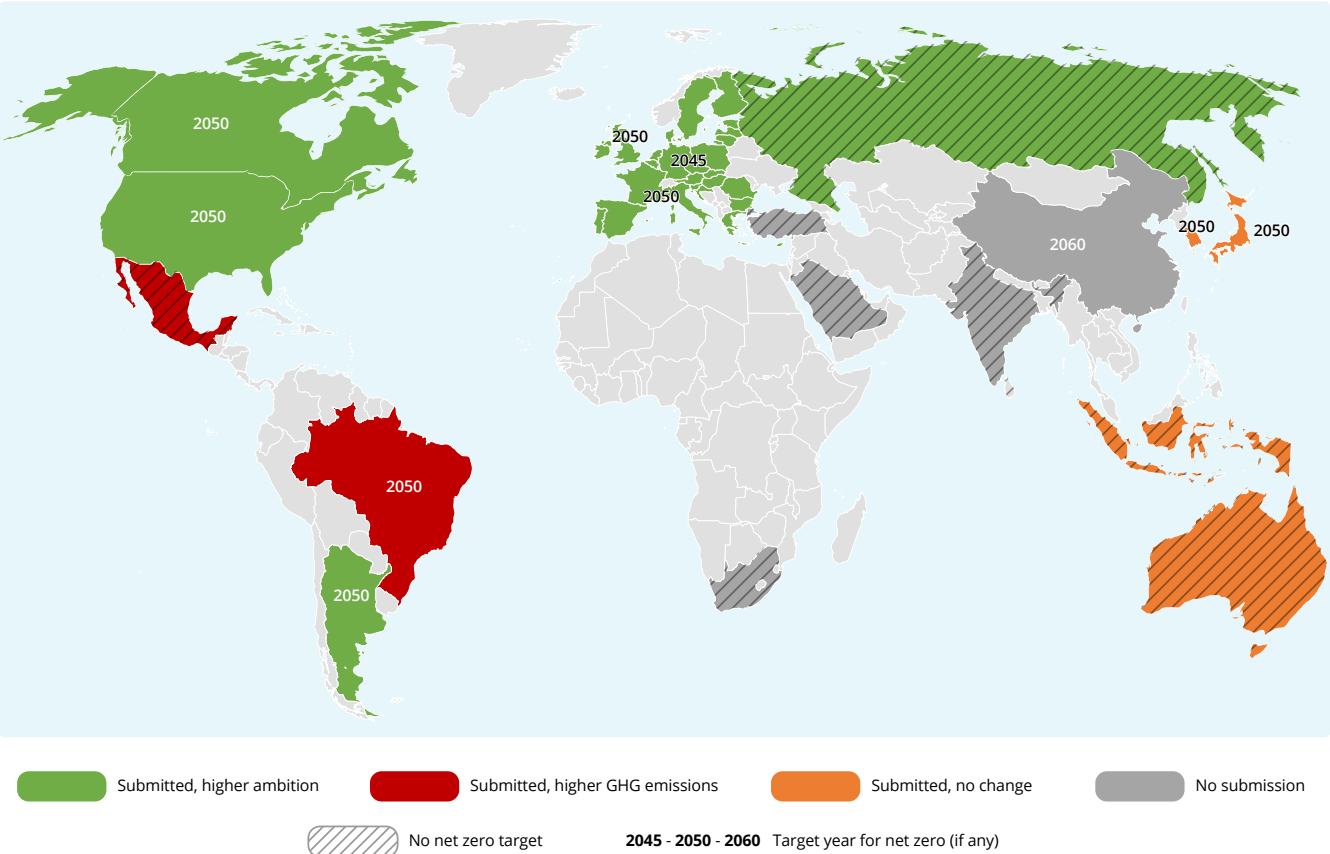
committed to any net zero targets. South Africa and Indonesia have both indicated intentions to move towards a goal of net zero emissions in their LT-LEDS. For a full summary of G20 climate commitments as of August 2021, see Table 1.

In advance of COP 26 in November 2021, G20 countries can demonstrate strong leadership under the Paris Agreement by putting forward ambitious and transformational plans that align with cutting global emissions in half by 2030 and reaching net zero emissions by mid-century. Together, aligned near- and long-term climate commitments from these countries will be essential for putting us on track to achieving the goal of the Paris Agreement.

To better understand the role that the G20 have to play in limiting future warming, this paper presents a set of scenarios that simulate different mitigation commitments made by G20 countries for 2030 and mid-century and the resulting impacts on global temperature rise. The scenarios include a reference scenario that depicts G20 commitments submitted as of December 2019, before new or updated 2030 emissions targets were expected, two current scenarios depicting interpretations of current G20 country commitments, and an enhanced ambition scenario depicting strengthened G20 commitments for 2030 NDCs and net zero targets for mid-century for all G20 members.

We outline details on the scenarios and how we construct them in the Methodology section below, before describing our results and what they mean in the context of global mitigation efforts in the lead up to the COP 26.

Figure 1: Mapping the current G20 climate commitments



The map shows nationally determined contributions (NDCs) submitted during the first update cycle under the Paris Agreement as well as whether or not countries have announced net zero targets and for when. Note: The European Union as a whole has a net zero target for 2050.

Source: Climate Action Tracker and World Resources Institute

Table 1. Summary of G20 climate commitments (as of August 2021)

Country	Share of global GHG emissions, 2018 (%) ^a	New or updated NDC submission status	Effect of new/ updated NDC on mitigation ambition	Long-term strategy	Net zero target
Argentina	0.8%	Submitted	Enhanced mitigation ambition	No submission	Net zero by 2050
Australia	1.3%	Submitted	No change	No submission	No target
Brazil	2.9%	Submitted	Higher GHG emissions	No submission	Net zero by 2050
Canada	1.6%	Submitted	Enhanced mitigation ambition	Submitted	Net zero by 2050
China	23.9%	No submission ^b	No submission ^b	No submission	Net zero by 2060
European Union	6.8%	Submitted	Enhanced mitigation ambition	Submitted	Net zero by 2050
France	EU	EU	EU	EU	EU
Germany	EU	EU	EU	EU	Net zero by 2045
India	6.8%	No submission	No submission	No submission	No target
Indonesia	3.5%	Submitted	No change	Submitted	No target ^e
Italy	EU	EU	EU	EU	EU
Japan	2.4%	Submitted ^c	No change ^c	Submitted	Net zero by 2050
Mexico	1.4%	Submitted	Higher GHG emissions	Submitted	No target
Russia	4.1%	Submitted	Enhanced mitigation ambition ^f	No submission	No target
South Africa	1.1%	No submission ^g	No submission	Submitted	No target ^e
Saudi Arabia	1.3%	No submission	No submission	No submission	No target
South Korea	1.4%	Submitted ^d	No changed	Submitted	Net zero by 2050
Turkey	1%	No submission	No submission	No submission	No target
United Kingdom	1%	Submitted	Enhanced mitigation ambition	Submitted	Net zero by 2050
United States	11.8%	Submitted	Enhanced mitigation ambition	Submitted	Net zero by 2050
G20 GHG % total:	73%				

Notes:

^a ClimateWatch 2021. <https://www.climatewatchdata.org/ghg-emissions>

^b At the 2020 Climate Ambition Summit, China announced an enhanced 2030 mitigation pledge but has not yet formally communicated it. China pledged to lower its carbon dioxide emissions per unit of GDP by over 65 percent from the 2005 level.

^c Japan announced an enhanced pledge at the Leaders Summit on Climate on 22 April 2021, committing to reduce GHG emissions by 46% from 2013 levels by 2030. Japan is yet to formally communicate its pledge.

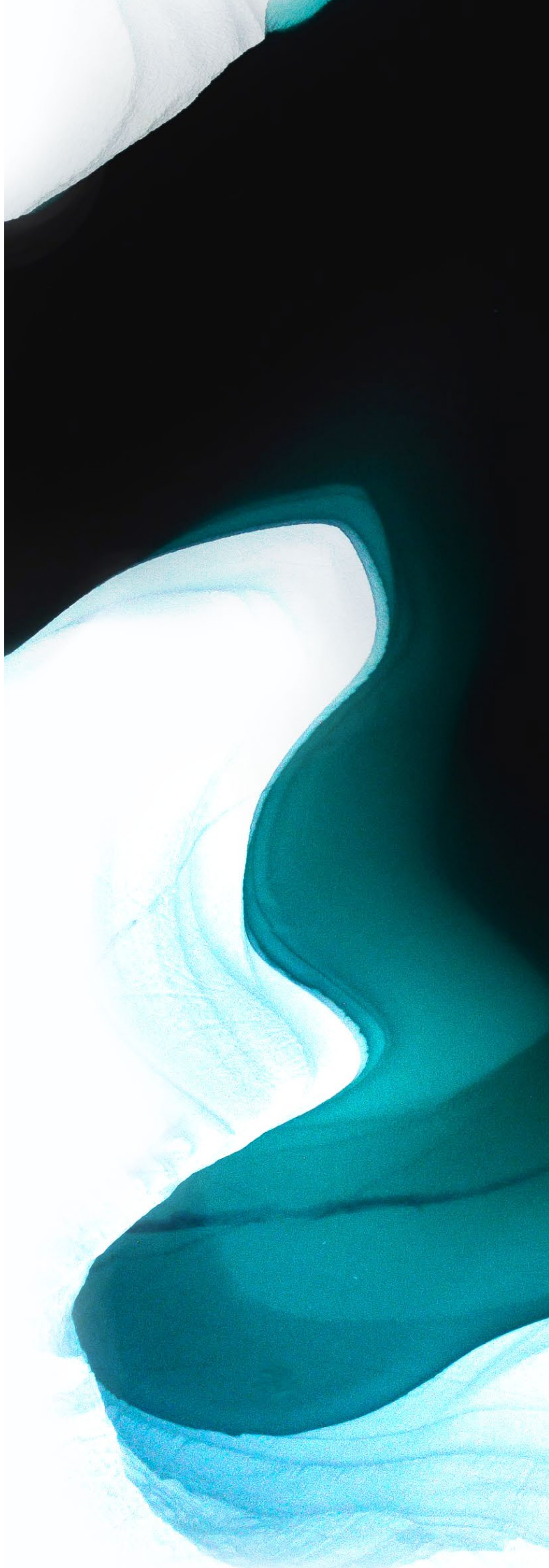
^d The Republic of Korea intends to submit an enhanced 2030 target by COP 26. <https://www.whitehouse.gov/briefing-room/statements-releases/2021/05/21/u-s-rok-leaders-joint-statement/>

^e Both Indonesia and South Africa expressed intentions to reach net zero emissions in their LT-LEDS. Indonesia's LT-LEDS mentions that the country is exploring the opportunity to rapidly progress towards net zero emissions in 2060 or sooner but has not formally committed to a net zero target. South Africa's long-term strategy indicates that the country will follow a 'peak, plateau, and decline' trajectory, capping 2050 emissions at 428 MtCO₂e though the document also mentions an intention to commit to 'net zero carbon emissions' by 2050 and indicates that the net zero goal is to be formally communicated in a future updated version of the LT-LEDS.

^f Russia pledged a 2030 emission reduction of at least 30% below 1990 levels while its previous reduction target had a range of 25–30% reduction below 1990. The revised NDC target is still less ambitious than what many modeling studies project under current policies.

^g South Africa released a draft updated NDC for public consultation in March 2021. The draft proposes enhanced 2030 emissions reduction targets (398-440 MtCO₂e) compared to the previous NDC. South Africa is yet to formally communicate an updated NDC to the UNFCCC.

Source: ClimateWatch 2021



3. Methodology

This analysis builds on the work of CAT, which estimates the collective effect of current NDCs on global emissions and their implications for temperature rise by the end of the century. Here we develop a scenario where G20 countries strengthen their emissions reductions by 2030 and mid-century. We then use CAT's methods to estimate what these strengthened mitigation commitments could mean for future warming levels. These methods are described in more detail below.

3.1. Scenario definitions

1. Reference scenario: In this scenario, G20 countries maintain the NDCs and long-term targets they had communicated to the UNFCCC as of December 2019 (CAT 2019).

2. Current and announced commitments scenarios: These two scenarios—one more restrictive and one more inclusive—depict the set of 2030 and mid-century targets put forward by governments during the second round of NDC submissions.⁵

- **Current commitments scenario:** The more restrictive 'current commitments' scenario includes
 - i. 2030 emissions reduction targets formally submitted in an NDC and
 - ii. net zero targets enshrined into national law.⁶
- **Announced commitments scenario:** The more inclusive 'announced commitments' scenario also includes
 - i. announced 2030 emissions reduction targets by the G20 that have not yet been formally submitted in NDCs⁷ and
 - ii. announced mid-century targets communicated in LT-LEDS and net zero targets committed to by G20 countries, regardless of their legal status.⁸

In both of these scenarios, if a country's current policies would result in lower 2030 emissions than its NDC target, we consider the former.⁹ For countries with a net zero target, we assume a linear trajectory from the 2030 target to the long-term target, regardless of the feasibility of such a trajectory.

For information on the targets included under each of the current scenarios, see Tables 1 and 2 in the Appendix.

- 3. Enhanced ambition scenario:** This scenario assumes that
- i. all G20 countries set 1.5°C-compatible targets for 2030 (see section 3.4 for more information on what this means) and
 - ii. all G20 governments that have not already set a net zero target for the year 2050 commit to one.

To reflect differences in development status and economic capability, we assume that all developed members of the G20 (defined here as including all Annex I countries and those categorised as high-income by the World Bank) achieve net zero GHG emissions by 2050, while developing G20 countries that have not yet adopted a net zero target achieve net zero CO₂ emissions in 2050. We include China's target of net zero GHG emissions by 2060, but also assume that China achieves net zero CO₂ in 2050 alongside other developing countries. For all other developing countries in this category, we assume that non-CO₂ emissions follow a domestic 1.5°C compatible trajectory. These assumptions do not indicate what a fair contribution from each country would be but, rather, show trajectories for achieving full decarbonisation on time. For information on G20 countries' net zero targets included in this scenario, see Table 3 in the Appendix.

Non-G20 Countries: In all scenarios, countries outside of the G20 are assumed to keep the NDCs and long-term targets they had as of May 2021.

3.2. Pathway development and temperature estimates

3.2.1. Constructing emissions pathways to 2100

To evaluate the long-term temperature implications of specific emissions reduction targets, complete emissions pathways until the end of the century are needed for all countries assessed under each scenario. Beyond the year of the last defined climate target, we construct an emissions projection to 2100 for each scenario by assuming that future mitigation effort remains consistent with the ambition of the target.

To do this, we apply the pathway extension method used by CAT¹⁰ to extrapolate regional emissions pathways to the point at which net zero (excluding land use, land-use change and forestry (LULUCF) emissions is reached. This method uses publicly available emissions pathway data from various Integrated Assessment Models (IAMs), which represent feasible techno-economic emissions pathways for the future world economy under various boundary conditions and mitigation ambition levels (IPCC 2014).

The pathway extension method assumes that the level of mitigation effort at any point in time corresponds to the relative position of an emissions pathway in a set of pathways from the IPCC AR5 database. For each scenario, the level of effort is set by the last available quantified target for each country (in 2030, 2050 or 2060, depending on the scenario). After the incorporation of all targets, the national pathways are aggregated to the regional level. The resulting regional emissions levels then define the selection of IAM pathways that have socio-economic and technological developments that could be considered consistent with the scenario, and a statistical approach representing these pathways is then used to extend the emissions trajectory until the end of the 21st century (Gütschow et al. 2018). This ensures that the long-term projection of a region is as consistent as possible with medium-term pledges.¹¹

Our estimates for the target emissions levels and associated pathways to 2100 include all GHGs but exclude emissions from LULUCF and international aviation and shipping (see Section 3.3 below). However, our net zero scenarios assume that the G20 countries rely on LULUCF removals to achieve net zero, which means that we need to make assumptions about the projected scale of land-use related emissions and removals for each country by 2050. These projections determine the strictness of what 'net zero' means for other emissions. Given high uncertainties in future land-use emissions and removals and the durability of land-based carbon storage in the face of climate change impacts, it is challenging to assess the levels of residual emissions that

governments expect to be balanced by removals in the land sector. The substantial mismatch between country-reported LULUCF emissions and removals and those considered as anthropogenic by IAMs also makes it very difficult to assess which global land-use pathways would be consistent with each scenario. To accommodate these high uncertainties, we have taken a relatively conservative approach that assumes a rapid decline in LULUCF emissions over the next decade, with the sector becoming a small global net sink in the second half of the century for all scenarios, following CAT's global pathway for LULUCF. We also use CAT's global pathways for emissions from international aviation and shipping, which depict slow emissions reductions in shipping and declining emissions growth for aviation, and hence are quite conservative.¹² If we were to assume faster mitigation action to reduce emissions and enhance removals in these sectors, the level of temperature rise would be lowered slightly.

In the second half of the century, all global 1.5°C compatible scenarios include some level of carbon dioxide removal (CDR) from the atmosphere, such that net global emissions fall to net negative later in the century (IPCC 2018). However, linking a country's medium-term emissions reduction efforts with a level of future CDR deployment is challenging. In our scenarios, we assume that, once countries achieve net zero emissions excluding LULUCF, they do not make additional efforts beyond this point. This limits the amount of CDR implicit in our scenarios to the amount needed to balance residual emissions after net zero has been achieved, for those countries with assumed net zero targets. Our conservative assumptions about the future role of CDR and LULUCF in conjunction with the scope of our analysis being limited to G20 countries results in emissions pathways that do not reach global net zero levels in this century. Relaxing either of the previously mentioned considerations would likely result in pathways that do reach net zero globally in this time frame. In order to halt continued increase in global warming, net zero emissions would need to be reached (IPCC 2018).

3.2.2. Assessment of global warming levels and emissions gaps for each scenario

We assess the global temperature increase in 2100 for each scenario by inputting each pathway into the climate model MAGICC V.6 (Meinshausen et al. 2011), and following the methods used by the CAT.¹³ All estimates for global temperature increase refer to the median (best estimate) climate model projection for a specific emissions scenario, within a range of climate system and carbon cycle uncertainty. Some studies refer to the level of warming that temperature rise is 'likely' to stay below (i.e., with a 66 percent chance) under a given pathway; such estimates would be higher than our median estimates. To enable a comparison of near-term mitigation efforts among scenarios, we also calculate the emissions gap in 2030 between each global emissions pathway and a representative 1.5°C compatible pathway. This allows us to compare the additional emissions reductions required to close this gap with the amount of mitigation effort needed to shift from a pathway based on the NDCs and LT-LEDS to date (CAT 2021a).

The representative global 1.5°C compatible pathway used for this analysis is the median of pathways from a filtered set of Paris Agreement compatible pathways. The IPCC SR1.5 defines global 1.5°C compatible pathways as those that limit warming to 1.5°C with no or limited overshoot (<0.1°C). In these pathways, the maximum increase in global average temperature above pre-industrial levels is limited to below 1.6°C, and end-century warming is limited to below 1.5°C (typically falling to around 1.3°C by 2100) (IPCC 2018). We take publicly available 1.5°C compatible scenarios from the IPCC's SR1.5 scenario database and then filter out those scenarios that exceed certain sustainability limits¹⁴ regarding the use of carbon dioxide removal. The resulting median pathway has an emissions level in 2030 of 27 GtCO₂e, which is roughly half of current emissions.

3.3. Net zero targets

To assess the impact of each national net zero target on national and global emissions pathways, we first need to estimate the residual emissions in the target year that are expected to be balanced by land-based removals. This assessment is necessary for the pathway extension method described earlier, which uses pathways that exclude emissions from LULUCF. It is also important for assessing whether emissions reduction targets would lead to the energy and industrial system transitions shown in 1.5°C compatible pathways.

For those G20 countries that already have a net zero target, we use CAT's assessments from May 2021 to estimate emissions in 2050 under these targets, excluding LULUCF, with some small adjustments (see Appendix, Table 4). Some targets are unclear in their scope, but in all cases, we assume that all GHG emissions are included. Only China has a target for 2060 in this set.

To assess the impact of potential targets for net zero by 2050 for those countries that have not yet made a commitment, we assume that in 2050, removals from LULUCF balance out remaining GHG emissions (for developed countries) or remaining CO₂ emissions (for developing countries). To estimate the potential LULUCF removals level for a country, we use any available national LULUCF projections or assume a continuation of the recent LULUCF sink, estimated using an average over the last 10 years. A more optimistic assessment of the future LULUCF sink in each country would, for the same target year, lower the stringency of the target for non-LULUCF emissions, and vice versa.

For developing countries that do not yet have a 2050 net zero target, we assume that they would achieve net zero CO₂ emissions in 2050. To estimate residual GHG emissions, excluding LULUCF, in 2050 for these countries, we need an estimate of the non-CO₂ emissions remaining in 2050. For this information, we use downscaled 1.5°C compatible non-CO₂ emissions pathways from IAMs.

3.4. 1.5°C aligned 2030 targets

For each of the G20 countries, Paris Agreement compatible 2030 targets are taken from the 1.5°C National Pathways Explorer, which provides 1.5°C compatible domestic emissions pathways at the national level (Climate Analytics 2021). These pathways are derived from a set of filtered global 1.5°C compatible emission pathways that represent possible technically and economically feasible futures. This set is filtered to exclude pathways that rely on very large-scale carbon dioxide removal (CDR), as described in Section 3.2.

We downscale these pathways from the regional level to the national level using a sectoral approach (downscaling different sectoral emissions separately) that follows the best practices of the integrated assessment and climate modelling communities (Gidden et al. 2019). This approach assumes that the economic, energy, and emissions characteristics of countries within a region converge at some future point in time (van Vuuren et al. 2007). We then assess the full distribution of downscaled outcomes to find the median (50th percentile) of country-level emissions pathways in order to form an upper limit for Paris Agreement compatibility for each country. More detail on the approach is also provided on the 1.5°C Pathways Explorer website (Climate Analytics 2021).

These domestic 1.5°C compatible pathways define what emissions reductions should be achieved domestically within each country in order to be in line with a globally cost-effective pathway that limits temperature rise to 1.5°C. They do not indicate what a fair contribution from each country would be but, rather, show trajectories for achieving full decarbonisation on time. For many developing countries, financial support from abroad will be needed to deliver the necessary pace of emissions reductions; hence, 2030 targets consistent with these domestic pathways could be expected to be conditional upon support. Developed country governments, on the other hand, have obligations to provide finance, technology transfer, and capacity building to those that need assistance. We do not assess that aspect in this analysis but note that, to make a fair contribution to meeting the Paris Agreement's goals, developed countries need not only reduce their own emissions, but also should provide international support to developing countries to enable them to achieve rapid emissions reductions in line with 1.5°C compatible domestic emissions pathways.

3.5. Uncertainties in our analysis

To undertake this analysis, we need to make several assumptions to estimate the effect of national targets on future national and global emissions pathways and the subsequent potential impact on temperature rise this century. Each of these assumptions is associated with uncertainties in our results. For example, we do not analyse potential future emissions and removals pathways in the land, aviation, and shipping sectors and, instead, assume that emissions in these sectors follow the global pathways used by CAT. Accelerated mitigation in these areas could bring down global emissions to net zero more quickly, further lowering potential warming estimates. On the other hand, a possible weakening of the future terrestrial sink as a result of worsening climate change impacts and land-use changes or a failure to develop low carbon aviation and shipping options could raise warming estimates.

There are also uncertainties in our assessment of the impact of near and longer-term targets on future emissions levels. The pathway extension method used for our analysis assumes that mitigation efforts continue after the latest climate target (2030 or 2050). Political, technological, and societal changes could accelerate or slow down these efforts, and spillover effects among countries could lead to faster emissions reductions at the global level.

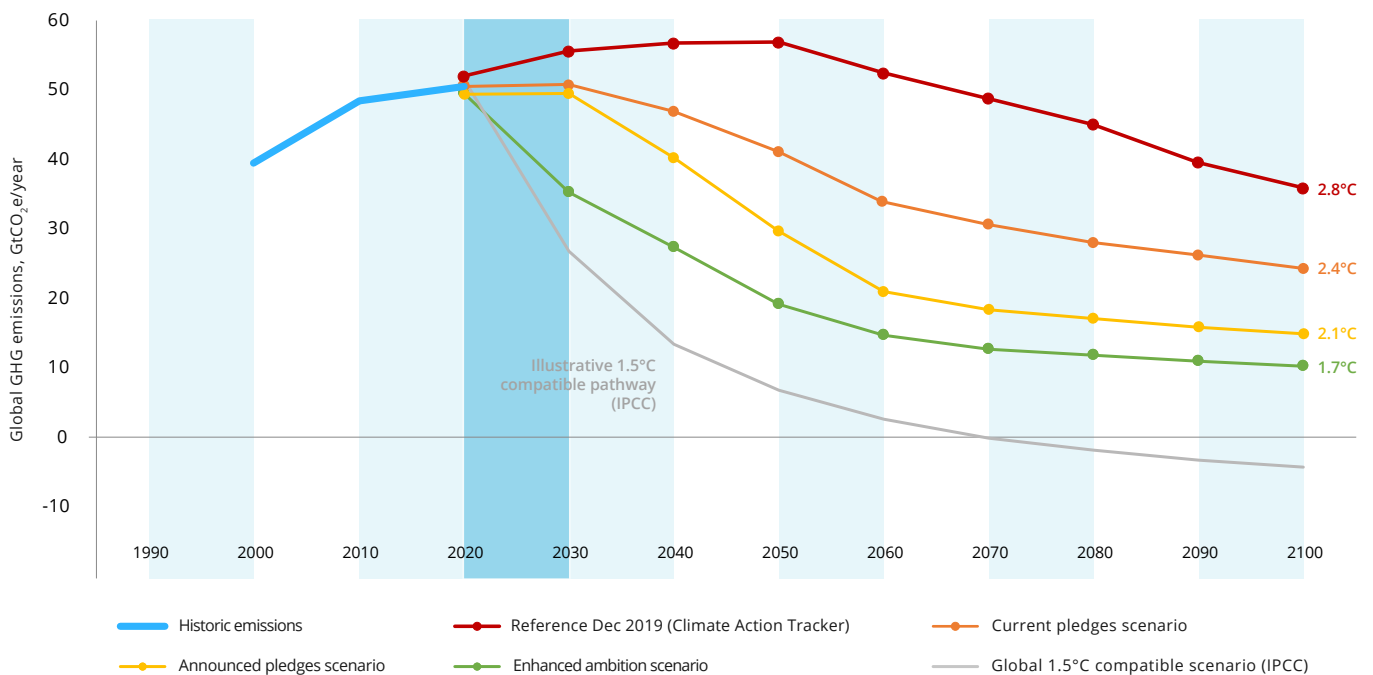
Further challenges arise in the interpretation of national targets. Some G20 NDCs and net zero targets are unclear in their scope (e.g., the emissions coverage of net zero targets), their impact on absolute emission levels in 2030, and/or the role of terrestrial sinks in meeting their targets, introducing uncertainties into our assessment of their effect on gross emissions, excluding the land sector. (See Climate Analytics (2019a) for more details.)

Finally, inherent in any assessment of temperature are climate cycle and other climatological uncertainties. All temperature values reported in this paper reflect the *median* probability that a given emissions trajectory will achieve a specified end-of-century temperature value; in other words, the emissions pathway is as likely as not to achieve that temperature outcome.

4. Results and discussion

Figure 2 presents the global emissions pathways through 2100 for each of the four scenarios, along with the estimates of end-of-century warming under each scenario. For comparison, we also show an illustrative 1.5°C compatible global emissions pathway (in grey); in this pathway, CO₂ emissions fall to net zero by 2050, and all global emissions fall to net zero before 2070, as defined as necessary by the IPCC (2018). Figure 3 shows how the global 2030 emissions gap (the difference between emissions in 2030 projected under each scenario and emissions compatible with a 1.5°C pathway) narrows under each scenario when compared with the gap in 2019 under the first set of NDCs.

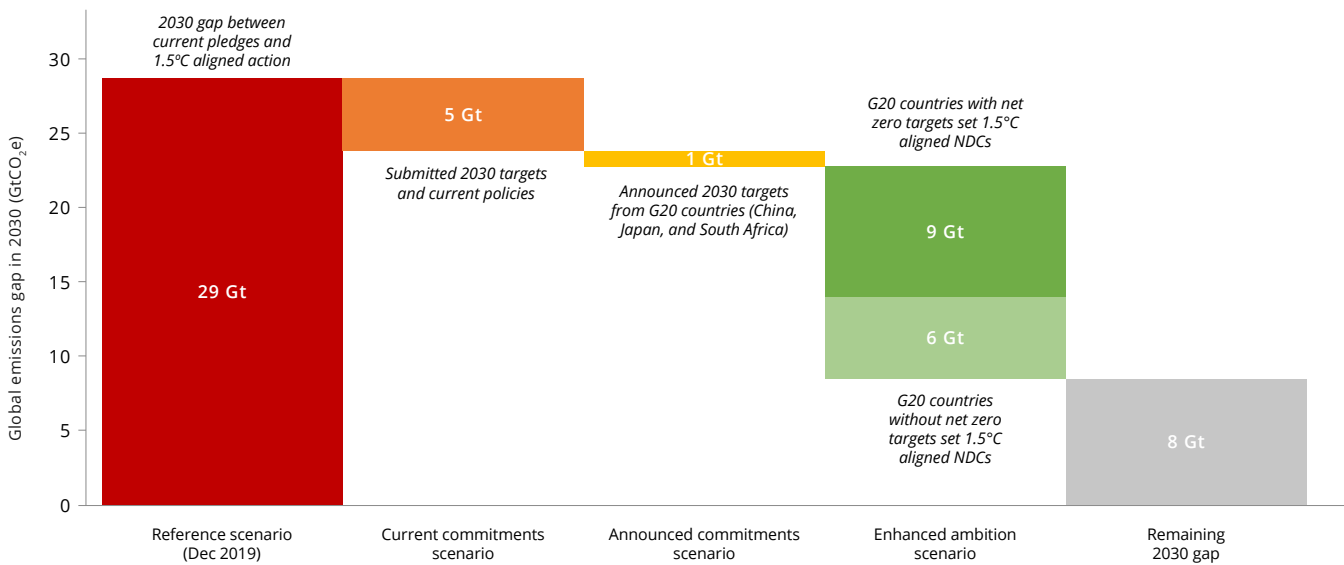
Figure 2: The impact of different G20 ambition levels on limiting global temperature rise



This figure shows the global greenhouse gas emissions pathways and corresponding warming levels in 2100 for each of the four scenarios in this report. For comparison, it also includes the median of 1.5°C compatible global emissions pathways as assessed by the Intergovernmental Panel on Climate Change. These pathways include emissions from all countries as well as from international aviation and shipping. Note that the 1.5°C global pathway reaches peak warming of below 1.6°C in the second half of the century, and returns to below 1.5°C with a 50% chance in 2100. Aside from this illustrative 1.5°C pathway, none of the scenarios reach net zero emissions before 2100, meaning that warming would continue into the next century.

Source: Climate Analytics and World Resources Institute, 2021. Data from the Climate Action Tracker and the Climate Analytics 1.5°C National Pathways Explorer

Figure 3: Most of the 2030 emissions gap can be closed by enhanced G20 ambition



The narrowing of the gap between global emissions in 2030 under each scenario and a 1.5°C pathway. In December 2019 the emissions gap between projected emissions in 2030 based on country pledges at the time and a 1.5°C pathway was estimated at 29 GtCO₂e (Climate Action Tracker). New policies and targets since then have reduced the gap by 6 GtCO₂e. Strengthened G20 nationally determined contributions (NDCs) that are aligned with national 1.5°C pathways could reduce this gap by a further 15 GtCO₂e, leaving a remaining gap of 8 GtCO₂e in the “enhanced ambition” scenario. To close this gap altogether, faster emissions reductions would be needed in non-G20 countries as well as in the land sector and international aviation and shipping.

Source: Climate Analytics and World Resources Institute, 2021. Data from the Climate Action Tracker and the Climate Analytics 1.5°C National Pathways Explorer

Our findings show that strengthening G20 targets, under the *enhanced ambition scenario*, could lower end-of-century temperature rise to 1.7°C. This drop of 0.7°C below the *current commitments scenario* is partly due to the strengthening of NDCs, with the 2030 emissions gap narrowing by 64 percent relative to the *current commitments scenario*, and partly due to all G20 members reaching net zero GHG or CO₂ emissions by 2050. This scenario illustrates the essential role that the G20 governments have to play in bending the global emissions curve downwards and keeping the Paris Agreement’s 1.5°C temperature limit within reach.

The following subsections go through the results of our scenarios before considering what else would be needed to fully close the emissions gap and limit warming to 1.5°C by the end of the century.

4.1. Progress in narrowing the gap

The pledges that were brought forward by governments in 2015 set the world on track for a temperature increase of around 3°C above pre-industrial levels by the year 2100, an extremely dangerous level of warming (Rogelj et al. 2016; CAT 2016a). Since then, some progress has been made, albeit not nearly enough.

Under the *reference scenario* for this analysis, estimated end-of-century warming, based on the NDC targets and policies in place by December 2019, was 2.8 °C, remaining far above the temperature limit agreed to under the Paris Agreement (CAT 2019).

Since December 2019, Parties have put forward new or updated NDCs and have increasingly committed to reaching net zero emissions by mid-century. As of 31 August 2021, 114 countries representing 50 percent of global GHG emissions have submitted a new or updated NDC, and an additional 51 countries (representing 30 percent of global emissions) have promised to do so. Of the 114 countries communicating new or updated NDCs, 67 countries (representing 32 percent of global emissions) submitted NDCs that would result in lower 2030 emissions relative to the previous NDCs (ClimateWatch 2021). In addition to NDC submissions, 48 countries have communicated a net zero target either in law, via a policy document, or as part of a political pledge since December 2019, bringing the total number of countries that have committed to net zero emissions to 63 (representing 54 percent of global GHG emissions) (ClimateWatch 2021).

Both our *current commitments* and *announced commitments scenarios* show that new or updated 2030 emissions targets and long-term net zero targets have made a significant but still insufficient dent in estimated warming levels.

Under our *current commitments scenario*, which includes NDCs that have been formally submitted and net zero targets enshrined in law, estimated end-of-century warming is 2.4°C. While the majority of new commitments have been made by smaller and more vulnerable countries, the drop in warming from 2.8°C to 2.4°C is largely driven by the 2030 and mid-century targets brought forward by a small number of G20 members: the United States' updated NDC and the EU's NDC and net zero target have the greatest impact; the net zero targets of Canada, Japan, and the United Kingdom and the enhanced NDCs from Argentina, Canada, and the United Kingdom also make a notable contribution to the estimated temperature drop in this scenario.

Our *announced commitments scenario* gives a more inclusive take on what governments have pledged and includes all announced 2030 emissions reduction targets and net zero emissions targets from G20 members that have not yet been formally submitted or written into law. Under this scenario, projected end-of-century warming is reduced further to 2.1°C. China's announced 2030 emissions reduction and net zero targets make a major contribution to the additional 0.3°C reduction in

this scenario (see also CAT 2020). The net zero targets announced by the United States, Argentina, South Korea, and South Africa,^{15 16} together with the announced and draft 2030 targets from Japan and South Africa,¹⁷ also play a role in the drop of estimated global temperature. This significant temperature drop illustrates the importance of ambitious long-term targets from these major emitting countries, who should formally communicate their targets to the UNFCCC via LT-LEDS and incorporate them into national policymaking to enhance their durability.

It is worth noting that while China's proposed 2030 target, which was announced in December 2020 as a 65 percent reduction in carbon intensity below 2005 levels by 2030, is estimated to have a relatively large impact on global emissions in 2030, it is only slightly more ambitious than the country's previous NDC and remains far from a Paris Agreement compatible trajectory to net zero before 2060 (CAT 2021b). Unless China strengthens its NDC, achieving net zero emissions before 2060 would require a very challenging pace of emissions reductions after 2030. China would need to accelerate its CO₂ and non-CO₂ emissions reductions in the 2020s, which will put China in a good position to reach its vision of net zero emissions by 2060. A number of other G20 members with net zero targets will also need to accelerate their emissions reductions over the next decade to improve the feasibility of achieving net zero in a manner consistent with the Paris Agreement.

A useful metric for assessing progress in keeping 1.5°C within reach is the emissions gap in 2030 between global emissions under a given scenario and those under a 1.5°C pathway. From 29 GtCO₂e in the *reference scenario*, this gap narrows to 24 GtCO₂e under the *current commitments scenario*, mostly due to strengthened G20 targets, but also due to non-G20 commitments and improved policies among those countries that are expected to overachieve their targets with their existing policies. The announced targets of China, Japan, and South Africa narrow this by a further 1 GtCO₂ to 23 GtCO₂e in the *announced commitments scenario* (see Figure 3). It is clear, then, that much stronger 2030 ambition is needed to close this gap and put emissions on a trajectory consistent with achieving stated mid-century goals.

4.2. Stronger ambition by all G20 members could keep 1.5°C within reach

The window of opportunity for narrowing the 2030 emissions gap and keeping 1.5°C within reach is closing. All of the world's major economies need to accelerate their transition to net zero. In our *enhanced ambition scenario*, all G20 members achieve net zero GHG (developed countries) or CO₂ (developing countries) emissions by 2050 and adopt enhanced NDC targets that are consistent with 1.5°C compatible domestic emissions pathways.

In this scenario, the 2030 emissions gap is reduced by 64 percent relative to our *current commitments scenario*, and our estimate for end-of-century temperature rise is 1.7°C—roughly 0.7°C lower than under the projected temperature rise of 2.4°C under current commitments.

These results show that further enhanced and ambitious G20 climate action over the next three decades could take us about three-quarters of the way to reaching the 1.5°C goal, from 2.4°C under our *current commitments scenario* down to 1.7°C. This illustrates the substantial turn of the temperature dial that could be realized through urgent action by the world's major economies in line with what is technically and economically feasible, provided that governments cooperate and make finance available where it is needed.

Looking at which governments could have the largest impact over the next decade, over half of the drop in emissions by 2030 achieved in this scenario comes from governments that already have a net zero target. By bringing their 2030 targets in line with a 1.5°C pathway to net zero, these governments could narrow the 2030 emissions gap by 9 GtCO₂e (see Figure 3).

To reflect differences in development status and economic capability, this ambitious scenario depicts developed G20 countries setting GHG net zero emissions for 2050, while developing countries reach net zero CO₂ emissions by 2050. (We also include China's target for net zero GHG emissions by 2060.) For information on G20 net zero targets included in this scenario, see Table 3 in the Appendix. Sensitivity tests in our analysis suggests that small shifts in the timing of these net zero targets would affect the temperature results to a much smaller degree than changes in the level of ambition in 2030, as it is the emissions level in 2030 that determines the trajectory towards net zero. The more emissions that are released before global net zero is achieved, the higher the maximum level of warming reached during this century will be.

Despite the stringency of G20 emissions reductions in our *enhanced ambition scenario*, global emissions do not fall to net zero before the end of the century, with 10 GtCO₂e/yr. remaining in 2100. This means that temperature would continue to rise after 2100. To bring global emissions to net zero and limit temperature rise to 1.5°C, collective action from non-G20 countries, together with stringent reductions in emissions from international aviation and shipping, will be needed. These actions will at least in part need to be supported by G20 economies. Nonetheless, this analysis illustrates the crucial role that ambitious action by G20 governments on both 2030 and 2050 time frames could have in achieving the long-term goals of the Paris Agreement. If G20 governments fall short on their commitments, efforts by other countries will likely not be sufficient to get global emissions on track.

4.3. Closing the G20 ambition gap to 1.5°C

The science is clear: limiting global temperature rise to 1.5°C requires halving GHG emissions by 2030 and getting to net zero CO₂ emissions by mid-century. Curbing emissions over this next decade is essential for enabling the 1.5°C limit to be met. Indeed, the higher emissions are in the near term, the greater and steeper the required emissions reductions after 2030 there will need to be to achieve net zero and prevent further temperature rise.

This analysis shows that new or updated NDCs brought forward by some individual G20 economies have a positive impact on reducing future estimated global temperature rise. Among the G20 countries, the European Union, United Kingdom, United States, Canada, and Argentina all submitted 2030 targets that are clearly stronger than their previous NDCs.

Despite this progress, new or updated 2030 emissions targets from a couple of G20 countries would lead to higher GHG emissions in 2030 than their previously submitted NDCs. Brazil and Mexico set targets that are the same percentage reduction as what they submitted in 2015 but allow a higher level of emissions in 2030 because of a change in their baseline.¹⁸

A number of other G20 economies have submitted new or updated NDCs that have zero impact on narrowing the gap to 1.5°C. Australia, Japan, South Korea, and Indonesia submitted identical GHG reduction targets to those submitted in 2015. Japan announced a 2030 emissions reduction pledge that is more ambitious than what it had put forward in its updated NDC in 2020, but the government is yet to officially communicate the revised targets to the UNFCCC via an updated NDC. South Korea submitted an updated NDC with a 2030 target that would result in the same level of emissions as the previous NDC, although the government announced its intention to revise its NDC and submit an enhanced 2030 target by COP 26. Russia's submitted update is marginally stronger than its previous NDC, but it still allows emissions in 2030 to be higher than where they are projected to be under Russia's current policies.

The remaining G20 countries, responsible for 34 percent of current global GHG emissions, have yet to submit new or updated 2030 emissions reduction targets. These countries are China,¹⁹ India, Turkey, Saudi Arabia, and South Africa.²⁰

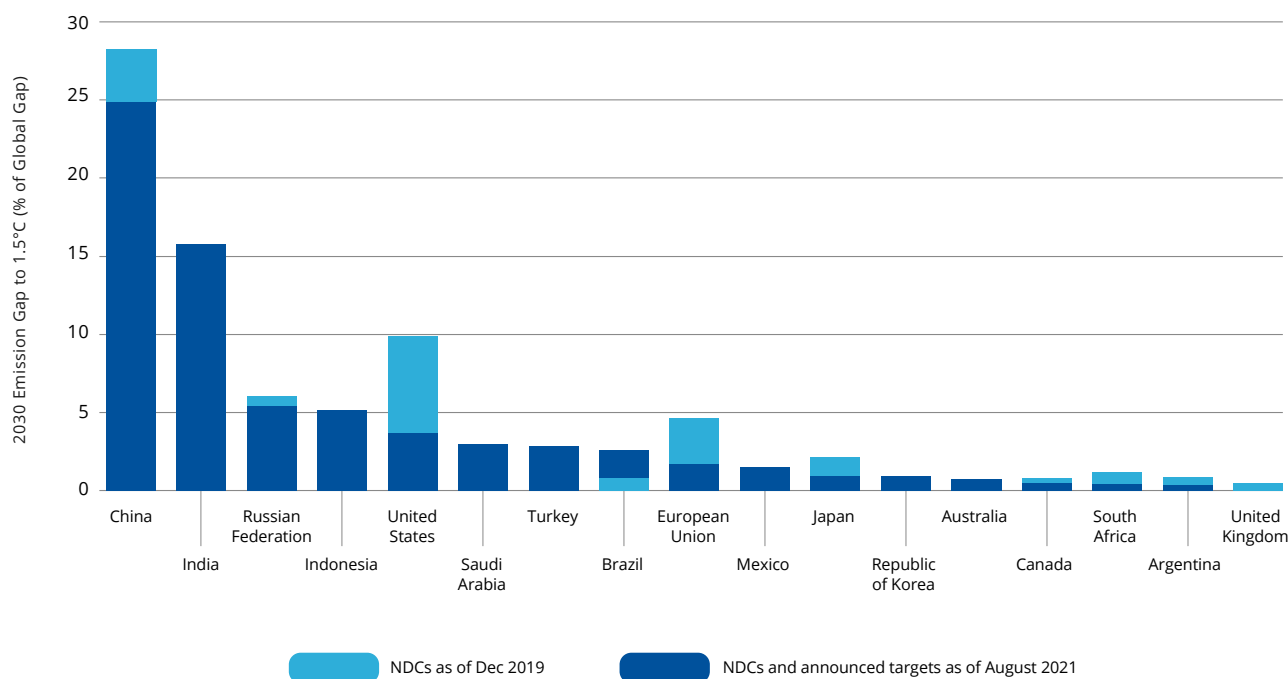
While strengthened 2030 emissions targets from some G20 economies had a positive impact on limiting warming, G20 economies' NDCs remain far off track from the emissions reductions necessary to be on a 1.5°C compatible domestic emissions pathway, both collectively and individually. Almost all G20 members

need to enhance their NDCs in order to reduce their emissions at a pace that is consistent with the ability to limit warming to 1.5°C and achieve a net zero emissions goal by mid-century. Only the United Kingdom is already on track for a 2030 domestic emissions reduction target that can be considered to be 1.5°C aligned, although the UK's policies are not yet sufficient to meet this target, and the country would need to provide much more climate finance to assist other countries in emissions reductions to make a fair contribution to the Paris Agreement (CAT 2021d; Climate Analytics 2021).

All remaining G20 governments will need to bring forward strengthened 2030 targets and net zero targets to keep the 1.5°C limit within reach. While new national commitments from G20 countries brought us closer to a 1.5°C compatible pathway, more major emitters should, at minimum, communicate enhanced 2030 emissions reduction targets of their own ahead of COP 26, including China, Japan, South Korea, Indonesia, India, Australia, Russia, and Saudi Arabia. Both Mexico and Brazil should also submit enhanced 2030 emissions targets, revising their recent updated NDCs that are less ambitious than the ones put forward in 2015.

Figure 4 shows how much of a gap remains between each country's current 2030 NDC emissions reduction targets and the 2030 emissions needed to align with a domestic 1.5°C pathway, given as a share of the global 2030 emissions gap. This illustrates how much progress each of the G20 countries have made in strengthening their 2030 targets and what further reductions are needed to get 2030 emissions onto a 1.5°C pathway. For more information on the 2030 ambition gaps of individual G20 nations, see Table 5 in the Appendix.

Figure 4: Emissions gaps in 2030 between G20 targets and 1.5°C domestic pathways



Emissions gaps in 2030 between G20 countries' nationally determined contributions (NDCs) and emissions levels in 2030 that would be consistent with a domestic 1.5°C pathway. NDCs as of 2019 as well as the most recent submitted or announced values are compared. The emissions data excludes land-use, land-use change and forestry emissions. G20 ambition gaps collectively make up about two thirds of the global gap in 2030 between where we're heading and a 1.5 pathway. Some countries have further to go than others to align with 1.5, and developed countries should provide support to help developing countries to close these gaps.

Source: Climate Analytics and World Resources Institute, 2021. Data from the Climate Action Tracker, including its Climate Target Update Tracker, and the Climate Analytics 1.5°C National Pathways Explorer

An important caveat is that this analysis does not take into account what a fair contribution to reducing emissions might be for each country, but rather focuses on the pace of decarbonisation needed to keep 1.5°C within reach. When principles of fairness are taken into account, developed countries are often considered responsible for very rapid emissions cuts that they may not be able to achieve domestically, in which case they have a responsibility to provide financing to enable developing countries to decarbonise as quickly as possible (CAT 2021e).

It will be important for developed countries to increase their climate finance and, at minimum, fulfill their commitment to mobilise \$100 billion annually to help developing countries get onto a 1.5°C compatible pathway and address their climate related needs. As it stands, international climate finance flows are not yet sufficient. Recent reports by the Organisation for Economic Co-operation and Development (OECD) and Oxfam show that developed countries are falling short of the \$100 billion goal, with the OECD reporting only \$78.9 billion in annual spending in 2018 and Oxfam estimating that \$59.5 billion per year was being provided in 2017–2018 (OECD 2020; Carty et al. 2020).²¹ It is worth noting that even with the provision of funding, least developed countries receive 14 percent of all climate finance, and small islands developing states receive only 2 percent (OECD 2020). Wealthier countries must urgently scale up their support, fulfill their commitment to providing \$100 billion per year, and ensure finance flows to those that need it most.

4.4. What more needs to be done to keep 1.5°C alive?

Accelerating emissions cuts to net zero

This analysis is based on what countries should do domestically to get on a 1.5°C compatible pathway but provides less information about how this transition may ultimately be facilitated and realized. Many countries will need support to align their efforts with these pathways. Support in the form of climate finance, technology transfer, and capacity building will play a key role in enabling all countries to decarbonise.

Meanwhile, the timing of global net zero emissions is directly related to the level of peak warming: the sooner net zero is achieved at the global level, the sooner global average temperatures will stop rising. Governments should therefore commit to net zero targets without delay and set as early a net zero target year as is feasible. This does not imply or require that all countries need to reach net zero emissions at the same time. In general, wealthier countries have the historical responsibility and economic and technological capability to set an earlier net zero date than developing countries and should also provide support to enable developing countries to decarbonise. As governments come forward with net zero commitments, it is particularly important that their targets be robust, durable, and comprehensive. To this end, it is critical that net zero targets be designed with good guidance in mind (Levin et al. 2020).

Perhaps most importantly, countries should pursue near-term action that is consistent with reaching net zero emissions. Indeed, setting a 2030 target that allows for a gradual transition to net zero emissions helps avoid locking in carbon-intensive economic pathways and can avoid costly rates of change in later years. Key near-term actions that governments should consider include halting construction of new coal power plants and phasing out coal power by 2040 (or 2030 for developed nations), phasing out combustion engine cars by 2035, ending fossil fuel subsidies, and rapidly accelerating renewables deployment over the next decade to decarbonise the power system by 2050 (Climate Analytics 2019b, 2019c; CAT 2016b).

Additionally, governments should clearly specify the scope and coverage of their net zero target, including which gases are covered, which sectors are covered, what the balance of gross emissions reductions and emissions removals may look like, and whether the country will allow offsets to count towards the target. The most robust long-term target would cover all greenhouse gases and sectors; specify a gross emissions reduction target for the same year as the net zero target, making clear the foreseen role of technological and biological carbon dioxide removal; and include provisions for avoiding or limiting the use of offsets to meet the net zero target. (CAT 2021c; Levin et al. 2020).

Finally, emissions from international aviation and shipping also need to be rapidly reduced. Only a handful of governments currently include these emissions in their net zero targets, and the international processes aimed at addressing emissions from aviation and shipping are currently inadequate. Accelerated mitigation in these sectors, which can be communicated through a thorough net zero target, will be essential.

Beyond the G20

Limiting warming to 1.5°C requires major transformation of our societies to rapidly reduce emissions. While it is essential that G20 countries take the lead in taking ambitious climate action without delay, all countries and nonstate actors need to strengthen their efforts as well. In the lead-up to COP 26, many non-G20 countries have already come forward with new or updated NDCs and committed to net zero emissions targets by mid-century, and vulnerable countries have taken tremendous leadership on that endeavour (see Box 1).

Emissions from non-G20 countries currently make up only about a quarter of global GHG emissions, but this share will grow as G20 countries decarbonise their economies unless the non-G20 follow suit, supported by international finance. Notably, technology spillover from countries on a net zero path may also accelerate emissions reductions in these countries, although we have not taken such effects into account in this analysis.

Box 1. Vulnerable countries lead the world on climate ambition

Vulnerable countries contribute a very small share of global GHG emissions, but many have already shown tremendous leadership and determined action on climate change. Certain efforts to curb 2030 emissions by small island developing states and least developed countries, such as Fiji, Jamaica, and Senegal, are ambitious, despite being least responsible for climate change, but they are still highly vulnerable to climate-change impacts. In addition, several countries have also committed to net zero emissions by mid-century. As of August 2021, 40 non-G20 countries, representing 3 percent of global GHG emissions, have set net zero targets by mid-century (ClimateWatch 2021).

5. Conclusion: a growing urgency for G20 governments to act

The IPCC Sixth Assessment Report, Working Group I report, released in August 2021, warns that devastating climate impacts will fundamentally change life on the planet and that these impacts are accelerating, while paths to achieve 1.5°C are narrowing. The results of this report emphasize the urgent need to accelerate action on climate change.

While recent commitments through updated 2030 NDCs by G20 countries, if fully implemented, would lower the projected global temperature rise down to 2.4°C (*current commitments scenario*), these results are still well above the Paris Agreement's 1.5°C temperature limit. It is therefore imperative that the emissions gap be closed with stronger 2030 targets and robust mid-century climate targets in order to avoid the worst climate impacts.

Our analysis shows that while all governments need to step up their climate commitments to reduce global emissions fast enough to be on a 1.5°C compatible pathway, G20 countries are uniquely responsible for avoiding that temperature threshold. If G20 countries take ambitious action to curb emissions by 2030 and

Mobilizing non-G20 countries will require not just ambitious and robust mitigation targets and policies, but also substantial financial and other forms of support. Developed countries should continue to take the lead and fulfill their \$100 billion per year commitment to international climate finance and ensure that finance goes to those developing countries that need it most.

There is currently a gap of 24 GtCO₂e for 2030 between where we are heading and where we need to be. If the world's major economies step up their near-term climate action, this could be narrowed by over 60 percent. In the lead-up to and during COP 26, the world will be watching. The G20 leaders need to acknowledge these gaps and commit to limiting global warming to 1.5°C by putting on the table enhanced 2030 emissions reduction and mid-century targets that are compatible with the Paris Agreement's 1.5°C goal and put in place the enabling conditions needed to make such targets achievable. Our findings show that such enhanced ambition by the G20 will be fundamental to keeping the 1.5°C limit within reach.

6. Appendix

Table 1. 2030 and mid-century emissions assumptions under the *current commitments scenario*

Country	2030 target	Source	Net zero target in law	Source
Argentina	Submitted NDC	UNFCCC 2021c	No net zero target in law	NA
Australia	Submitted NDC	UNFCCC 2021c	No net zero target in law	NA
Brazil	Current policies more stringent than NDC	CAT 2021d	No net zero target in law	NA
Canada	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	Canadian Net zero Emissions Accountability Act 2021
China	Submitted NDC	UNFCCC 2021c	No net zero target in law	
European Union	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	European Climate Law 2021
India	Current policies more stringent than NDC	CAT 2021d	No net zero target in law	NA
Indonesia	Current policies more stringent than NDC	CAT 2021d	No net zero target in law	NA
Japan	Current policies more stringent than NDC	CAT 2021d	Net zero GHG in 2050	Act on Promotion of Global Warming Countermeasures (Japanese) 2021
Mexico	Submitted NDC	UNFCCC 2021c	No net zero target in law	NA
Russia	Current policies more stringent than NDC	CAT 2021d	No net zero target in law	NA
Saudi Arabia	Current policies more stringent than NDC	CAT 2021d	No net zero target in law	NA
South Africa	Current policies more stringent than NDC	CAT 2021d	No net zero target in law	South Africa's Low Emission Development Strategy 2020
South Korea	Submitted NDC	UNFCCC 2021c	No net zero target in law	NA
Turkey	Current policies more stringent than NDC	CAT 2021d	No net zero target in law	NA
United Kingdom	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	The Climate Change Act 2008 (2050 Target Amendment) Order 2019
United States	Submitted NDC	UNFCCC 2021c	No net zero target in law	NA

Table 2. 2030 and mid-century emissions assumptions under the *announced commitments scenario*

Country	2030 target	Source	Net zero target	Source
Argentina	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	Climate Ambition Summit 2020
Australia	Submitted NDC	UNFCCC 2021c	No target	NA
Brazil	Current policies more stringent than NDC	CAT 2021d	Net zero GHG in 2050	Leaders Summit On Climate 2021
Canada	Submitted NDC	UNFCCC 2021 ^c	Net zero GHG in 2050	UNFCCC 2021; Canadian Net zero Emissions Accountability Act 2021 ; Climate Ambition Summit 2020
China	Announced 2030 target	Government of China 2020	Net zero GHG in 2060	Climate Ambition Summit 2020; Ministry of Foreign Affairs of the Peoples' Republic of China. 2021
European Union	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	European Climate Law 2021; Long-term low GHG development strategy of the European Union and its member states 2020
India	Current policies more stringent than NDC	CAT 2021d	No target	NA
Indonesia	Current policies more stringent than NDC	CAT 2021d	No target ^a	NA
Japan	Announced 2030 target	Government of Japan 2021	Net zero GHG in 2050	Act on Promotion of Global Warming Countermeasures (Japanese) 2021; Japanese Prime Minister Suga Yoshihide's announcement 2020; The Long-term Strategy under the Paris Agreement 2019
Mexico	Submitted NDC	UNFCCC 2021c	No target	NA
Russia	Current policies more stringent than NDC	CAT 2021d	No target	NA
Saudi Arabia	Current policies more stringent than NDC	CAT 2021d	No target	NA
South Africa ^b	Draft NDC	Government of South Africa 2021	Net zero CO ₂ in 2050	South Africa's Low Emission Development Strategy 2020
South Korea	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	2050 Carbon Neutral Strategy 2020
Turkey	Current policies more stringent than NDC	CAT 2021d	No target	NA
United Kingdom	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	The Climate Change Act 2008 (2050 Target Amendment) Order 2019
United States	Submitted NDC	UNFCCC 2021c	Net zero GHG in 2050	Updated First NDC 2021; Executive Order on Tackling the Climate Crisis at Home and Abroad 2021

Notes:

^a At the time of analysis, Indonesia did not have a net zero target. In July 2021, Indonesia submitted its LT-LEDS, which indicates that Indonesia is exploring scenarios for net zero by 2060 or earlier, which will inform future NDC revisions.

^b South Africa's LT-LEDS includes an intention to commit to 'net zero carbon emissions' by 2050, and indicates that the net zero goal is to be formally communicated in a future updated version of the long-term strategy. Thus, we still do not consider South Africa as formally committed to reaching net zero emissions by 2050. In June 2021, South Africa's climate commission proposed a stronger NDC target and recommended that South Africa indicate its commitment to a net zero goal as part of the NDC. For this analysis we have interpreted the potential target as being for net zero CO₂ emissions, but this remains to be clarified.

Source: Authors.

Table 3. Net zero assumptions under the *enhanced ambition scenario*

Net zero target type	Countries
Net zero GHG by 2050	Argentina, Australia, Brazil, Canada, EU 27, UK, Japan, South Korea, Saudi Arabia, Turkey, United States
Net zero CO ₂ by 2050 and net zero GHG by 2060	China
Net zero CO ₂ by 2050	Indonesia, India, Mexico, South Africa

Table 4. LULUCF assumptions for estimating the impact of net zero targets on emissions

Country	LULUCF emissions in year of net zero (MtCO ₂ eq/yr.), and explanation of assumptions/sources
Argentina	-32 Ginzo (2015), mitigation scenario by 2050.
Australia	-53 CAT Scaling Up Australia report (-53 is consistent with stopping deforestation in 2030, and is enough for net zero by 2050)
Brazil	-711 Forum Climate Brasil report
Canada	-10 BUR4 projection to 2030 used for 2050
China	-783 Average historical sink (2004–2014)
European Union	-298 EU Commission's 1.5TECH scenario, minus UK sink
India	-70 Historical sink estimate from Grassi et al. (2021), which excludes soils
Indonesia	0 We could not find a source that could justify a sink by 2050.
Japan	-35 Extrapolated historical 2009–2018 trend from national inventory
Mexico	-10 Projected sink from the conditional NDC scenario in the Energy Policy Solutions explorer
Russia	-243 Based on the 'with measures' scenario to 2030 from Russia's BR4 report.
Saudi Arabia	0 We could not find a source that could justify a sink by 2050
South Africa	-16 Average historical sink (2005–2015)
South Korea	-17 Extrapolated historical 2008–2017 trend to 2030, assuming this level remains constant to 2050.
Turkey	-70 Based on the 'with measures' mitigation scenario for 2030 from Turkey's BR4 report.
United Kingdom	-19 Climate Change Committee's 'Balanced scenario' for 2050
United States	-634 Extrapolated 1990–2018 trend to 2050

Table 5. Ambition gap between G20 current targets and 1.5 °C compatible emissions level for 2030.

For each country, the gap is calculated as the difference between the maximum estimate of emissions under the current 2030 target from the Climate Action Tracker and the least stringent end of the range of 1.5°C compatible emissions levels from the 1.5°C National Pathway Explorer. Gaps are shown as a percentage of the global emissions gap in 2030 and as a percentage of emissions under each country's current target. For countries that, as of August 2021, have announced but not yet formalised new targets (China, Japan, South Africa) this assessment is based on the existing NDC, not the announcement. (CAT 2021d, Climate Analytics 2021)

Country	Ambition gap in 2030	
	(% of global gap)	(% of emissions under current target)
Argentina	<0.5	27
Australia	1	37
Brazil	2.6	47
Canada	<0.5	24
China	28	47
European Union	2	17
India	16	67
Indonesia	5	68
Japan	2	47
Mexico	1	46
Russia	5	53
Saudi Arabia	3	65
South Africa	1	44
South Korea	1	40
Turkey	3	68
United Kingdom	0	0
United States	4	21

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8. Endnotes

- 1 All warming estimates in this paper are given as the median level of warming in 2100 associated with a given emissions pathway, meaning that there is a 50percent likelihood that warming will be at or below that level.
- 2 In cases where a country's current policies would result in lower 2030 emissions than its NDC target, we consider the former.
- 3 The 20 governments constituting the G20 are Argentina, Australia, Brazil, Canada, China, the European Union, France, Germany, Italy, India, Indonesia, Japan, Mexico, the Republic of Korea, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, and the United States.
- 4 Most of these net zero targets are for net zero GHG emissions, but some are for net zero carbon dioxide emissions only.
- 5 The cutoff date for this scenario is May 2021 for non-G20 countries and July 2021 for G20 countries. As of the time of writing this paper, no major announcements or pledges were made by G20 countries (beyond May 2021) that would affect the result of this analysis. The latest G20 members to submit NDCs and LT-LEDS were Canada, which officially submitted its NDC on 12 July 2021, maintaining the same 2030 pledges announced at the Climate Leaders' Summit in April 2021, and Indonesia, which submitted its updated NDC and LT-LEDS on 21 July 2021. Indonesia's updated NDC maintained the same 2030 emissions target as its previous NDC.
- 6 This scenario includes the net zero targets of Canada, the European Union, Japan, and the United Kingdom, which had enshrined their net zero targets in law as of August 2021. To maintain consistency with the reference scenario, this scenario also includes long-term strategies in place as of December 2019, before the latest set of submissions.
- 7 Announced 2030 emissions targets not yet formally submitted in NDCs include those brought forward by China at the 2020 Climate Ambition Summit, Japan at the Leaders Summit on Climate in April 2021, and South Africa's draft updated NDC in March 2021.
- 8 For the purposes of this analysis, we do not include the net zero targets of non-G20 countries if they have not been enshrined in law.
- 9 Under some cases, there is uncertainty in the emissions level associated with a country's NDC, for example when an NDC is composed of multiple targets. A lack of information means that we need to make our own assumptions to assess the effect of the NDC on emissions. This is also the case when there is uncertainty over the contribution of emissions from LULUCF. In such cases, we take the upper end of our calculated range of emissions levels under the NDC to provide a conservative estimate. For a full description of the assumptions made for each NDC, see the Climate Action Tracker country pages and their assumptions tabs: <https://climateactiontracker.org/countries/>.
- 10 For a full description of the pathway extension methodology refer to the Climate Action Tracker methodology page, see <https://climateactiontracker.org/methodology/global-pathways/>.
- 11 For more detailed information, please see Geiges et al. 2020:
- 12 For more information on the CAT's pathways for LULUCF and aviation and shipping, see <https://climateactiontracker.org/methodology/global-pathways/>.
- 13 For more information on the CAT's methods for estimating global temperature rise, see <https://climateactiontracker.org/methodology/global-pathways/>.
- 14 We use global sustainability limits for the most widely modeled CDR options by 2050, identified in the IPCC SR1.5 to be below 5 GtCO₂ p.a. for bioenergy with carbon capture and sequestration and below 3.6 GtCO₂ p.a. for sequestration through afforestation and reforestation, while noting the uncertainty in the assessment of sustainable CDR potentials later in the century (Fuss et al. 2018; IPCC 2018).
- 15 South Africa's LT-LEDS includes an intention to commit to "net zero carbon emissions" by 2050, and indicates that the net zero goal is to be formally communicated in a future updated version of the long-term strategy. Thus, we still do not consider South Africa as formally committed to reaching net zero emissions by 2050. In June 2021, South Africa's climate commission has proposed a stronger NDC target and recommended that South Africa indicate its commitment to a net zero goal as part of the NDC. For this analysis, we have interpreted the potential target as being for net zero CO₂ emissions, but this remains to be clarified.
- 16 Brazil's net zero target has little impact on global emissions in 2050 in our analysis because of the large assumed land sink in 2050, which allows emissions to continue at a relatively high level. This is based on an independent report as the Brazilian government does not provide any detail on how it will achieve its net zero target. (See Appendix for assumptions.)
- 17 South Africa did not technically announce 2030 emissions-reduction target although this scenario considers the 2030 emissions-reduction targets included in South Africa's draft updated NDC (398–440 MtCO_{2e}), released in March 2021.
- 18 Both Brazil and Mexico's 2030 targets look the same as in their 2015 NDC: a 43 percent cut from 2005 emissions and a 22 percent cut relative to business-as-usual emissions, respectively. The updated NDCs, however, contain revisions to the reference-level emissions that reduce the impact of their targets on 2030 emissions: Brazil increased its estimate of 2005 emissions by 38 percent, while Mexico increased its business-as-usual projection by 1.8 percent. As a result, 2030 emissions under the pledges will yield higher GHG emissions than they would under both countries' initial NDCs.
- 19 At the Climate Ambition Summit on December 12, 2020, President Xi Jinping announced 2030 targets, although he did not explicitly refer to an NDC. In this announcement, President Xi stated that, by 2030, China commits to reducing carbon emissions per unit of GDP by over 65 percent from 2005 levels.
- 20 South Africa has indicated that it will submit a stronger target before COP 26.
- 21 Oxfam noted that even this amount is likely to be largely inflated and that climate-specific net assistance may be just \$19–\$22.5 billion per year in 2017–2018.

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