ARE G20 COUNTRIES DOING THEIR FAIR SHARE OF GLOBAL CLIMATE MITIGATION?

COMPARING AMBITION AND FAIR SHARES ASSESSMENTS OF G20 COUNTRIES' NATIONALLY DETERMINED CONTRIBUTIONS (NDCS)

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As the group of the world's largest economies and biggest emitters, G20 countries are central to implementing solutions to the climate emergency. This discussion paper assesses to what extent they are setting climate mitigation targets that are ambitious enough and/or meet their fair share of global emissions reductions consistent with limiting global heating to 1.5°C. It applies three different methodologies to assess their pledges. Despite some differences between these methodologies, the paper finds that the G20 countries – both collectively, and almost all of them individually – are failing to achieve their fair share of ambitious global mitigation required to limit global heating to 1.5°C, regardless of which assessment methodology is applied. Additionally, the assessment shows that the high-income G20 member countries are pledging to do a much smaller fraction of their fair share as compared to the middle-income countries. The G7 countries among the G20, in particular, appear to now be focusing their attention on the increase of ambition of middle-income and low-income countries while not recognising the need to also substantially increase the ambition in their own 2030 pledges. Additionally, the G7 countries continue to fail to recognise the need to commit to individual long-term climate finance to low and middle-income countries, at a scale much higher than what they currently provide, to enable rapid and just transitions to climate-resilient and low-carbon societies powered by renewable energy. This analysis highlights that G20 countries must both urgently, and before COP28 in December 2023, raise the ambition of their pledges for action by 2030, ramp up their provision of international climate finance and increase their international cooperation and support.

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[1] For transparency, it should be noted that the author of this discussion paper is an employee of the Climate Equity Reference Project (CERP) and a current author (with Tom Athanasiou and Sivan Kartha) of the Climate Equity Reference Framework, one of the assessment approaches discussed in this paper.

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EXECUTIVE SUMMARY

The climate crisis is accelerating, and the most disadvantaged communities are feeling the brunt of it. Whether the UK breaching 40°C temperatures for the first time ever, devastating typhoons in the Philippines, flooding in Pakistan, drought in East Africa or forest fires across North America, it is people living in poverty – both in lower- and higher-income countries – who suffer the worst consequences.

Limiting global heating to an average temperature increase of 1.5°C above pre-industrial levels is still possible, but in the words of the UN Secretary General, 'it will take a quantum leap in climate action'. According to the IPCC, cutting emissions to limit global heating to 1.5°C requires 'rapid and far-reaching transitions' across all sectors of the global economy by 2030.

Yet current emissions reductions targets put forward by the world's governments are nowhere near this level of ambition: instead of the 45% cut in global greenhouse gas (GHG) emissions by 2030 that the IPCC says is necessary to limit global heating to 1.5°C, the latest United Nations Framework Convention on Climate Change (UNFCCC) Nationally Determined Contributions (NDCs) synthesis report indicates that the current targets imply a 10.6% global rise in emissions by 2030.

In 2023, the Paris Agreement's Global Stocktake will take place. This will review whether countries' climate action targets, pledges and actions are on track to meet the Paris Agreement's objectives to limit global temperature increase to 1.5°C (and hold it to well below 2°C), to increase adaptation and resilience to climate impacts, and to make financial flows consistent with these mitigation and adaptation objectives. The Global Stocktake is explicitly tasked to conduct this review 'in the light of equity', with the intention to then guide countries to enhance the ambition of their actions and their international cooperation and support. The insights from this analysis can serve as useful contributions to the Global Stocktake.

The assessment in this paper is based on the explicit commitment that the world's governments have made under the Paris Agreement: to pursue efforts to ensure global temperature increase is limited to 1.5°C above pre-industrial levels. This metric is an important accountability tool, but the current level of heating, around 1.1°C–1.3°C, is already deeply unsafe for many communities across the globe, violating their human rights to life, food, water, housing, and many other rights, so 1.5°C should not be treated as a floor for climate ambition.

G20 countries are home to the world's largest economies as well as the majority of the people of this planet (63%). They also generate most of the world's greenhouse gas (GHG) emissions (78%). Their actions will therefore have a decisive impact on the global success of addressing the climate emergency.

The paper compares three approaches to assessing the fairness and/or ambition of governments' greenhouse gas reduction targets (NDCs). It then applies these methodologies to the most recently available G20 emissions reduction targets, to assess their ambition and/or fairness, and to discuss the significance of substantial differences in assessments between approaches. Utilizing different approaches is helpful in judging the strength of the conclusions: if all approaches share similar results and support similar conclusions, it suggests that they are robust. Conversely, if certain results are not shared across the approaches, then additional analysis and interpretation of the differences would be needed. We did not find the latter to be the case generally.

- The first of the benchmarking approaches, the Climate Action Tracker (CAT), has been selected because it is a widely used resource that assesses countries' mitigation pledges and policies. This report uses one element of the CAT's hybrid benchmarking system, the 'effort sharing range', which the CAT derives from effort sharing calculations extracted from a large body of academic effort sharing literature that reflects a broad range of views of what might be fairness in effort sharing.

- The second approach, the Climate Equity Reference Project (CERP) framework for fair effort sharing, has been selected because it is the effort sharing approach utilized by the Civil Society Equity Review, an ambition assessment initiative whose initiation Oxfam was centrally involved in. The CERP approach is based on the specific view that equitable effort sharing needs to incorporate all relevant equity principles of the UN climate regime: responsibility for creating the climate crisis; capabilities for addressing it; and the right to sustainable development.

- The third benchmarking approach, Equal-Per-Capita-Consumption-CO_2 (EPCCC), has been selected as it has been used in recent Oxfam research on carbon inequality. Importantly, this approach does not reflect any fairness or equity considerations, but it can serve as a 'quick glance' ambition metric (but not equity metric) to assess whether countries are planning to engage in a sufficient level of domestic mitigation in line with 1.5°C pathways.

The assessments of the fair share benchmarking approaches show that the G20 – both collectively, and almost all of them individually – are failing to achieve their fair share of ambitious global mitigation required to limit global temperature increase to 1.5°C. The assessments from all three approaches also show that none of the individual NDC targets of high-income G20 countries represent the level of ambition required for a 1.5°C global mitigation pathway, and their shortfalls are generally much bigger than for middle-income countries.

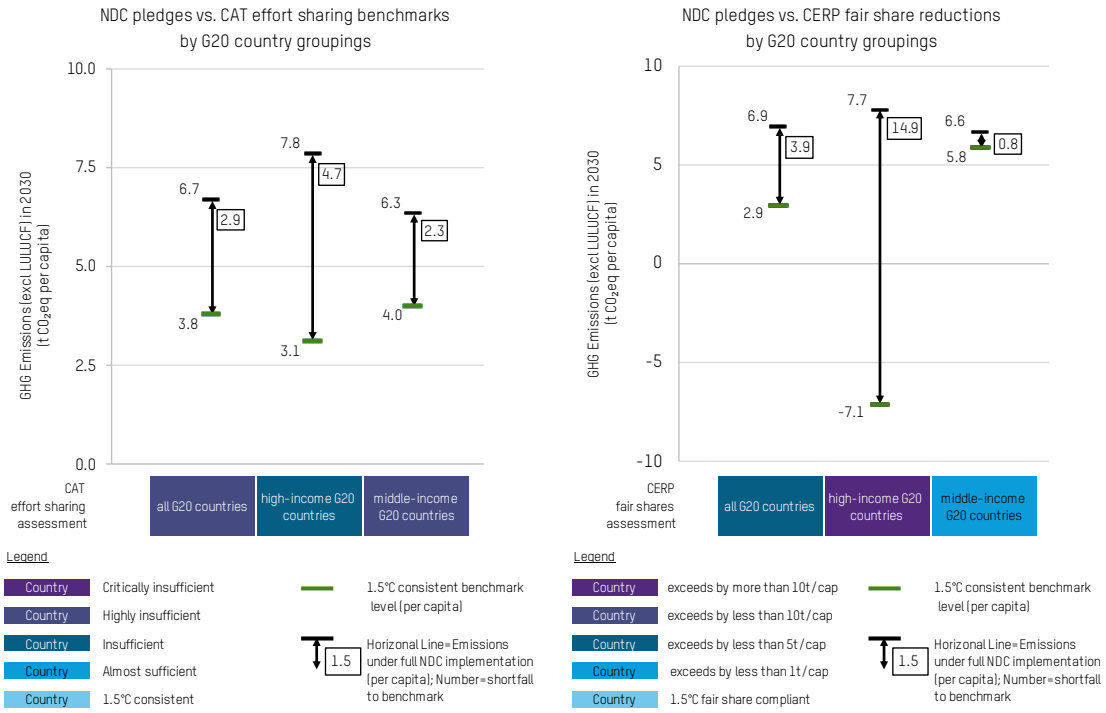
Figure 1 and Table 1 show the results for the CAT and CERP benchmarking approaches for the G20 as a group, as well as for high- and middle-income G20 countries separately. Note that these two approaches utilize different methodologies and rating systems (see section 2.2) and therefore cannot be compared directly. The shortfall of the G20, as a group, between its collective NDCs and the fairness and/or ambition benchmarks of the three approaches ranges from 2.8 tons of carbon dioxide (tCO_2) per capita (EPCCC; not shown in Figure 1) to 2.9 tons of carbon dioxide equivalent (tCO_2eq) per capita (CAT) and 3.9 tCO_2eq per capita (CERP) in 2030. (Carbon dioxide equivalent, CO_2eq, measures different greenhouse gases in a single unit. CO_2eq signifies the amount of CO_2 that would have the equivalent global warming effect over a certain period of time as a particular quantity and type of one or more greenhouse gases, such as methane and nitrous oxide).

Given the projected population of the G20 of 5.1 billion people in 2030, this would translate to an overall absolute excess of emissions in 2030, in G20 countries alone, of 14.1bn tons of CO_2 (EPCCC) to 14.6bn tons of CO_2eq (CAT) and 20.2bn tons of CO_2eq (CERP). Comparing these figures with the global shortfall of 20–23bn tons of CO_2, as calculated by the UN Environment Programme's Emissions Gap Report, shows how dramatically G20 countries will need to increase their mitigation ambition to be in line with limiting global temperature increase to 1.5°C.

However, it is important to also consider the results for G20 countries in a more nuanced and differentiated fashion. Even though all the G20 countries are among the largest economies in the world, there is a large degree of inequality between these countries. High-income G20 countries have the primary historic responsibility and technological capability and financial capacity to mitigate the climate crisis. There are also inequalities in terms of GHG emissions, wealth, per capita income levels and poverty rates. When looking at the high-income countries within the G20, across all three assessment approaches used, those countries' shortfall vis-à-vis their 1.5°C-consistent benchmarks is much, or very much, larger than the shortfall of middle-income G20 countries, ranging from about twice as large (CAT, EPCCC) to 18 times as large (CERP).

In high-income countries such as the USA and Australia, for example, the emissions levels that would result from implementing their pledged reductions are still far higher than what their fair share would dictate. To meet their fair share benchmark under the CERP framework, they would have to enhance their 2030 NDC targets to reduce an additional 240% (USA) and 170% (Australia), respectively, of their current NDC target emissions level. Likewise, under the CAT assessment, Germany and the UK would need to further enhance their 2030 NDC emission reduction targets by 160% (Germany) and 124% (UK), respectively, and Russia by 60%, to receive the '1.5°C compatible' CAT effort sharing rating for their 2030 target. Perhaps counterintuitively, the CAT approach gives a

Figure 1. Left panel: Summary of results of the CAT effort sharing assessment; Right panel: Summary of results of the CERP fair shares assessment



Sources: Left panel: based on data from CAT; Right panel: based on data from the Climate Equity Reference Calculator. Both panels are aggregated for G20, high-income G20, and middle-income G20 countries. Green horizontal dashes show the 1.5°C-consistent per capita emissions levels in 2030 (benchmark) for each country aggregation. The horizontal black dash shows the per capita emissions level in 2030 that would result from the implementation of the NDCs of each country in the group. The arrow between the green and black dashes shows the shortfall between benchmarks and NDCs, and the number label box shows the size of this shortfall in tons of CO_2eq per capita. Blue country group label boxes are colour-coded to reflect the assessment labels for each approach; black font and lighter shades for NDCs that are more, white font and darker shades for NDCs that are less, aligned with benchmarks. See Figure 7 for summary results for EPCCC approach. Australia, Canada, the EU, France, Germany, Japan, Italy, Saudi Arabia, South Korea, the UK and the USA are high-income G20 economies. The other G20 members are middle-income countries.

less negative rating ('insufficient') to high-income G20 countries collectively than to middle-income G20 countries ('highly insufficient'), and to the G20 overall ('highly insufficient'), despite the latter two having less per capita shortfall between their NDCs and their CAT benchmark than high-income G20 countries. This is because the ranges of emissions corresponding to each of CAT's rating categories are much wider for higher-income countries compared to lower-income countries, making it easier for the former to receive more favourable ratings compared to the latter with the same absolute shortfall relative to the CAT 1.5°C benchmark (see section 2.3).

As illustrated by these results, assessment methods that foreground equity show that high-income countries would need to reduce emissions well above 100% by 2030 in order to be aligned with typical fair share results. Thus, even if these countries reduce their domestic emissions to zero by 2030, they would still fall short of these fair share benchmarks. This in turn means that to meet their fair share of global mitigation, they additionally would have to provide substantial amounts of climate finance and technological and other support, in order to facilitate further emissions reductions in other countries at a scale that corresponds to the remaining shortfall relative to their fair share. Importantly, however, providing such support would not be an alternative to reducing domestic emissions as rapidly and deeply as possible, but would be additional to such reductions, and reflects the fact that high-income countries have already emitted more than would be consistent with their fair share of global mitigation. For the purpose of assessing high-income countries' contributions against their mitigation fair share, this means that ideally such assessments would include their domestic mitigation pledge *and* their pledges, if available, for climate finance and support. However, since high-income countries have long refused, and

continue to refuse, to make commitments at the UNFCCC about the finance and support each of them will provide in the future (beyond a very short timeframe of a few years), such complete assessments remain impossible.

Table 1. Summary of main assessment metrics and ratings for aggregates of all G20, high-income G20, and middle-income G20 countries

	G20			High-income G20 countries			Middle-income G20 countries		
Approach	***CAT***	***CERP***	***EPCCC***	***CAT***	***CERP***	***EPCCC***	***CAT***	***CERP***	***EPCCC***
Unit	tCO_2eq/cap	tCO_2eq/cap	tCO_2/cap	tCO_2eq/cap	tCO_2eq/cap	tCO_2/cap	tCO_2eq/cap	tCO_2eq/cap	tCO_2/cap
Current emissions	7.4	7.7	14.1	12.0	12.3	5.3	6.1	6.3	8.9
NDC emissions 2030	6.7	6.9	5.1	7.8	7.7	6.8	6.3	6.6	4.5
1.5°C benchmark 2030	3.8	2.9	2.3	3.1	-7.1	2.3	4.0	5.8	2.3
Shortfall	2.9	3.9	2.8	4.7	14.9	4.5	2.3	0.8	2.2
Rating according to approach	Highly insufficient	Exceeds by less than 5t/cap	Exceeds by less than 4 times	Insufficient	Exceeds by more than 10t/cap	Exceeds by less than 4 times	Highly insufficient	Exceeds by less than 1t/cap	Exceeds by less than double

Table shows aggregates for each benchmarking approach: current per capita emissions, per capita emissions in 2030 under NDC implementation, per capita emissions under each approach's 1.5°C benchmark, per capita shortfall between NDC and benchmark, and rating according to each approach. Appendix provides the same information for each individual G20 country.

Middle-income G20 economies such as Indonesia, South Africa, Brazil, China and Mexico have lower historic responsibilities for the climate crisis and less financial capacity available to address it. But this analysis shows that middle-income G20 countries collectively, as well as many individually, are also failing to achieve their fair and/or ambitious share of global emissions targets; this needs to be addressed by countries adopting emissions reductions targets that are at least consistent with the benchmarks discussed here, if the world is to limit global heating to 1.5°C.

As a result of decades of insufficient climate action on the part of the high-income G20 countries, their fair share emissions reductions are now so large, often in excess of 100% of their current emissions by 2030, that they can no longer be carried out solely within the borders of these countries. For 1.5°C-consistent global mitigation to remain possible, middle- and low-income countries must therefore also be willing to implement mitigation that is more ambitious than what their fair share would require. However, as it would be unjust to expect middle- and low-income countries to implement these deeper cuts with their own resources, such additional cuts must be facilitated by substantial climate finance and support from high-income countries.

Based on this paper's overall approach, it is clear that all G20 countries need to enhance the ambition of their mitigation efforts. This is significant, because the three assessment methodologies follow substantially different approaches for assessing the ambition and/or fairness of countries' mitigation pledges, but this overall conclusion holds. Collectively, countries' mitigation targets are so far from the required level of ambition that increased domestic mitigation ambition and enhanced international cooperation is needed in every country. For the high-income G20 countries, in addition to enhancing domestic targets, this means significantly ramping up climate finance and other cooperation and support, so that middle-income G20 countries, as well as other middle- and low-income countries, can reduce their emissions even further than they could be fairly expected to, or would be practically able to, with their own resources alone.

These insights are important now as the Global Stocktake will be finalized by the end of 2023 at COP28. Since the Global Stocktake aims to guide countries in enhancing the ambition of their own climate action as well as, for high-income countries, ramp up their provision of international climate finance and international cooperation, the analysis can help identify which countries need to enhance their action and support the most, and by how much.

The continued failure of G20 countries to meet their ambitious and/or fair shares of global emissions reduction target is deepening the climate crisis. This not only has devastating consequences for people's lives, but it is also deeply unjust as it is low-income communities and marginalized groups that suffer the brunt of climate inaction. There is still time to prevent runaway climate change. G20 countries, as well as the rest of the world, have much to gain from increasing the ambition and equity of climate action. If mitigation ambition, including the provision of sufficient climate finance, is not enhanced in the next few years, the remaining 1.5°C carbon budget will have been used up and the window to hold heating below 1.5°C will have closed. The time to do so is now.

INTRODUCTION

The climate crisis is accelerating and the most disadvantaged communities are feeling the brunt of it: whether it is the UK breaching 40°C temperatures for the first time ever, devastating typhoons in the Philippines, flooding in Pakistan, drought in East Africa, or forest fires across North America, it is people living in poverty – both in lower- and higher-income countries – who suffer the worst consequences.

Limiting global heating to an average temperature increase of 1.5°C[1] above pre-industrial levels is still possible, but in the words of the UN Secretary General, 'it will take a quantum leap in climate action'.[2] According to the IPCC, cutting emissions to limit global heating to 1.5°C would require 'rapid and far-reaching transitions' across all sectors of the global economy by 2030.[3]

Yet current emissions reductions targets put forward by the world's governments are nowhere near this level of ambition: instead of cutting global emissions by the required 45% by 2030,[4] the latest United Nations Framework Convention on Climate Change (UNFCCC) Nationally Determined Contributions (NDCs) synthesis report indicates that the current targets imply a 10.6% global rise in emissions by 2030.[5]

In 2023, the Paris Agreement's Global Stocktake will take place. This will review whether countries' climate action targets, pledges and actions are on track to meet the Paris Agreement's objectives: to limit global average temperature increase to 1.5°C (and hold it to well below 2°C); to increase adaptation and resilience to climate impacts; and to make financial flows consistent with these mitigation and adaptation objectives. The Global Stocktake is explicitly tasked to conduct this review 'in the light of equity'[6] with the intention to then guide countries to enhance the ambition of their actions and their international cooperation and support.

Focusing on one aspect of this overall challenge, this discussion paper aims to assess to what extent the governments of the world's largest economies in the G20 are setting targets that are ambitious and/or that meet their fair share of global emissions reductions consistent with limiting global heating to 1.5°C. The insights from this analysis can serve as useful contributions to the Global Stocktake.

The paper explains and compares three approaches (Climate Action Tracker, Climate Equity Reference Framework, Equal-Per-Capita-Consumption-CO_2) that are used to assess the fairness and/or ambition of governments' greenhouse gas (GHG) reduction targets (NDCs). It then applies these methodologies to the most recently available G20 emissions reduction targets, to assess their ambition and/or fairness, and to discuss the significance of substantial differences in assessments between approaches.

The paper utilizes these three substantially different approaches with a view to understanding the similarities and differences between the methodologies and their assessments. Utilizing different approaches is helpful in judging the strength of the conclusions: if all approaches share similar results and support similar conclusions, then it suggests that they are robust. However, if certain results are not shared across the approaches, then further analysis and interpretation of the differences are needed.

The rest of the paper is structured as follows. Section 2 briefly outlines why the three assessment approaches have been selected for this analysis, before then describing each of these approaches in detail, including summaries of their main shortcomings. The main differences and commonalities across the approaches are then discussed. These explanations are necessary to equip the reader with the necessary background knowledge to be able to interpret the results of each approach. Subsequently, Section 3 presents the results of the equity and/or ambition analysis for G20 countries for each of the approaches, while Section 4 offers conclusions and their implications. The appendix presents more detailed results for each G20 country individually.

Most quantitative results in this paper are presented in tons of GHG emissions per capita (tCO_2eq/cap or tCO_2/cap) in 2030.[7] These numbers are based on the total relevant emissions in each country in 2030 (e.g. the emissions level required to satisfy a benchmark, or the emissions level implied by the NDC) divided by the projected population of the country in 2030, using the UN Population Division's medium variant projections.[8] The use of per capita figures is appropriate because otherwise a comparison between countries of vastly different population sizes would be strongly biased by population. The focus on 2030 is appropriate as all the NDCs of G20 countries use 2030 as the mitigation target year.

2 AMBITION AND EQUITY ASSESSMENTS OF MITIGATION PLEDGES

2.1 SELECTION OF AMBITION ASSESSMENTS AND FAIR SHARES ASSESSMENT APPROACHES

The effort sharing literature,[9] both in academic journals and in grey literature reports, is a mature body of work which continues to evolve with new studies and approaches being elaborated.[10] Several other approaches to assessing the ambition and/or fairness of countries' mitigation targets exist beyond the three selected here.[11] A study utilizing and comparing all the approaches that have been previously proposed is far beyond the scope of this paper, and therefore using a subset is inevitable.[12] Two of the approaches used in this paper have been chosen because they are widely used by civil society, media and/or governments: the Climate Action Tracker (CAT) and the Climate Equity Reference Project (CERP) framework. These two approaches reflect, to some degree, some interpretations of what countries' fair contributions to addressing the global climate crisis should be and how that compares to the mitigation pledges they have been making. In addition, the results from another approach, which is not based on fairness considerations but can serve as a simple ambition assessment metric, are shown to complement the study. This latter approach, the Equal-Per-Capita-Consumption-CO_2 (EPCCC), is included because it has been utilized in recent Oxfam research on carbon inequality, [13] to facilitate comparison across Oxfam papers.

It is important to note that while all three approaches offer insights into the ambition of countries' mitigation targets relative to certain ambition benchmarks, not all of them utilize defensible equity or fairness criteria to derive these benchmarks. The EPCCC approach cannot be characterized as an equitable approach to benchmarking at all and is not used in this report as an equity metric. The metric was devised as a single, simple, 'quick glance' global benchmark to contextualize the emissions inequality findings of recent Oxfam/SEI work and was not intended as an equity benchmark by its authors.[14] Using it as an equity benchmark is contrary to the UNFCCC's and Paris Agreement's equity principle of 'common but differentiated responsibilities and respective capabilities' and the right to development.[15]

The CAT combines information from the academic effort sharing literature with other metrics, with the resultant hybrid benchmark, on which its headline assessment is based, only partly derived from equity considerations. However, in addition to the headline hybrid assessment results, which determine the well-known "traffic light" ratings on the CAT website, the raw data for CAT's effort sharing assessment is also publicly available. Here, we use the latter as the main CAT data source as it is more relevant for this paper's purpose. The CERP framework results are exclusively based on the equity principles of the UN climate convention and the specific parameters utilized in this discussion paper largely follow those used by the Civil Society Equity Review, thus representing the consensus of what should be considered 'fair' of the civil society organizations and social movement groups behind the Review. However, like with every approach to calculate fair shares or equitable effort sharing benchmarks, the determination of whether a given approach is actually fair lies with the reader, as no universally agreed interpretation of the UNFCCC's equity principles exists.

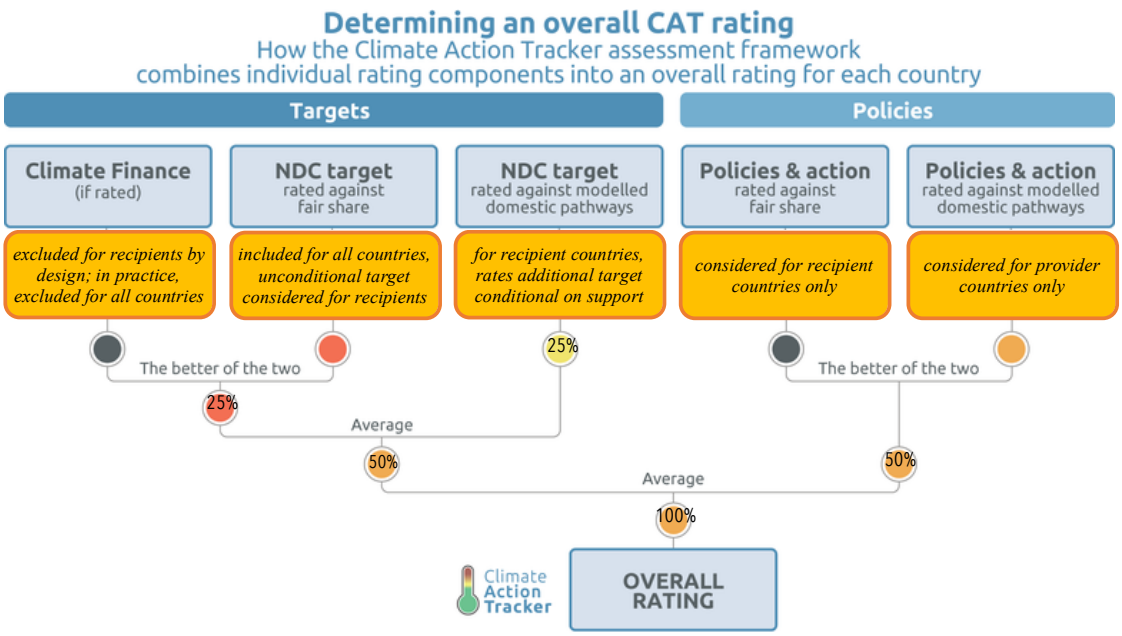
Since some of the approaches considered here are based on equity considerations, while others are not, the neutral term 'benchmarking approaches' is used to refer to them collectively, as they all establish benchmarks for each country against which the equity and/or ambition of its mitigation pledges can be assessed.

2.2 PRINCIPLES AND METHODS OF BENCHMARKING APPROACHES

2.2.1 Climate Action Tracker (CAT)

The CAT is a widely-used resource that, since its inception in 2009, provides assessments of countries' mitigation pledges and policies. Initially, these assessments were based exclusively on CAT's effort sharing, or 'fair share' benchmarks, in turn based largely on data from effort sharing studies in the published academic literature. In its September 2021 methodology update,[16] CAT moved away from a pure effort sharing assessment in favour of a hybrid ambition assessment, in which the assessment of a country's NDC against the effort sharing benchmark is only one of several metrics that informs a country's CAT rating. The other metrics are whether the NDC target and/or national policies are aligned with an emissions benchmark downscaled from modelled mitigation pathways ('modelled domestic pathways'),[17] the provision of climate finance (high-income countries) or the articulation of a deeper mitigation goal conditional on climate finance (lower-income countries). As a result, the CAT's 'fair share range', which prior to the update was the sole benchmarking metric, now forms the basis for only one (for high-income countries) or two (for lower-income countries) of the five assessment pillars, and the five pillars are combined into the single hybrid assessment result in a way that gives fair share-based pillars only 25% (in the case of higher-income countries) or 75% (for lower-income countries) weight in the final result (Figure 2).

Figure 2. The Climate Action Tracker's hybrid ambition benchmarking algorithm



Source: Adapted from CAT[18] by adding each step's total weight (percentages in the coloured circles) and typical inclusion/exclusion (in orange text bubbles). 'Recipients' = countries expected to receive climate finance; 'provider countries' = countries expected to contribute climate finance; terms roughly equivalent to 'developing' and 'developed' countries, respectively.

The CAT website provides data files of the raw data for the effort sharing assessment component of its hybrid ambition assessment. Since this discussion paper is mostly interested in CAT's metrics for the effort sharing benchmark, only this effort sharing component has been used in the main figures, but the results of the hybrid assessment are also shown, where relevant. The reason for this is that the results of the *hybrid ambition assessment* can only be expressed in CAT's 'traffic

light' qualitative rating scale (ranging from '1.5°C consistent' to 'critically insufficient'); they cannot be expressed in terms of a *quantitative* shortfall relative to the benchmark. On the other hand, the results of the *effort sharing* component can be expressed in a *quantitative* mitigation shortfall in tons of CO_2eq per capita between NDC pledge and effort sharing benchmark, thus affording comparison with the other two approaches.

Therefore, whenever talking about CAT results, this paper always specifies whether the figures and results refer to the 'CAT effort sharing assessment/benchmark' or to the 'CAT hybrid ambition assessment'. This difference is important for long-term users of CAT ratings to understand, because CAT has been most widely known for its effort sharing/fair share assessment of countries' pledges. Since September 2021, however, CAT's top-line country ratings are based on the hybrid ambition assessment, and not anymore on the effort sharing assessment alone.

CAT's effort sharing benchmarks are broadly derived from the academic literature by collecting effort sharing studies (as well as adding additional proprietary datasets from CAT consortium members) and algorithmically combining the datasets of these studies into a single effort sharing benchmark. CAT's authors justify this approach with their desire to avoid 'deciding on an approach to determine what's fair', and instead calculate a metric that reflects the spectrum of effort sharing analyses found in the academic literature, and use a simplified climate assessment to find emission levels implying various global heating levels (like 1.5°C) relative to that range. However, as a result of this approach, it is impossible to articulate the precise (or even general) view of 'fairness' or 'justice' that is represented by the CAT effort sharing benchmarks because vastly different, and even contradictory, perspectives have been merged to derive the benchmark. This includes some perspectives that Oxfam does not consider acceptable fair share approaches (e.g. equal-per-capita or 'grandfathering').[19,20]

While many (though not all) of the underlying data points of the CAT effort sharing benchmarks are based on peer-reviewed studies, the CAT methodology (neither the original nor the updated methodology) has not been published in the peer-reviewed literature, though the original methodology built upon a study led by one of CAT's co-founders,[21] and an article describing the current version of the effort sharing component of CAT's hybrid assessment is currently under review for academic publication.[22]

2.2.2 Climate Equity Reference Project (CERP) 1.5°C fair shares assessment

The CERP[23] effort sharing framework determines each country's fair share of the global effort (in this case, the global mitigation effort consistent with limiting global temperature increase to 1.5°C) in proportion to the country's responsibility for causing the climate emergency (expressed as a country's responsibility for historical GHG emissions) and its capacity to act to address it (expressed as a country's GDP). In this approach, capacity is understood in a progressive way, where the incomes of the poorest people count less (or not at all) towards the country's capacity than the incomes of those who are not poor or wealthy, whose incomes count more (or fully) towards the country's capacity (Box 1). In Oxfam's view, the CERP approach is the method that is closest to internationally agreed principles of climate justice on common but differentiated responsibilities and respective capabilities, the right to development, universal human rights and eradication of poverty.

Users can fine-tune the framework to reflect their specific interpretation of what is fair in terms of the responsibility and progressivity of the capacity dimension. Different groups have typically selected 1850 or 1950 as the starting point for counting historical GHG emissions by countries toward their responsibility, and used several different interpretations of how to implement progressivity for the capacity dimension. Progressivity in this context carries the same meaning as used when talking about national income tax regimes, most of which are 'progressive' in that they include a lower bracket of income below which no income tax is paid, a portion above this bracket where tax rates progressively increase as individuals' incomes increase, up to a top bracket, which differentiates the top incomes from all others and above which tax rates no longer increase with income.

For this paper, Oxfam chose 1950 as the historical responsibility start date, which is also utilized for one of the benchmarks of the Civil Society Equity Review (CSER), as well as for the benchmarks of US Climate Action Network's Fair Share project. The progressivity settings of another of the Review's benchmarks were used, where incomes below US$7,500 (2005 PPP) per person per year (about US$20/day) are excluded from a nation's capacity, and where the rate to which incomes are included gradually rises on incomes above this US$7,500 threshold until they reach the maximum rate at US$50,000 per person per year.

The annual Civil Society Equity Review that was initiated prior to the Paris group by a large number of civil society groups and social movements, including Oxfam, is utilizing this framework to assess the fairness and ambition of countries' NDCs. The CERP methodology has been published in peer-reviewed literature.

The CERP approach's main shortcoming lies in its use of baselines to define the globally shared mitigation effort, as it conceptualizes total global mitigation as the distance between the global mitigation pathway (e.g. a 1.5°C pathway) and a no-effort baseline (a counterfactual projection of how countries' emissions would develop in the absence of mitigation policies and measures). The results of the CERP effort sharing calculations are sensitive to the specific baseline projections used, though the overall findings (i.e. which countries fall far short of their fair share benchmarks and which are roughly in line) tend to be robust to baseline variations. This problem (sensitivity to baselines) is shared among all effort sharing approaches to equity benchmarking. The main ways in which the CERP approach's use of baselines can be considered a potential shortcoming are the 'shrinking time horizon' and 'current emissions' bias.

The 'shrinking time horizon' problem can have a strong impact on results if the start date of emissions reductions is close to the year for which the assessment is carried out. For example, if an assessment for mitigation targets for 2030 is carried out today in 2023, and assumes emissions reductions start from current (2023) emissions levels, then the currently unequal emissions profiles of countries would have a strong impact on the results as there would only be a short period of time (7 years) for countries to diverge from current unequal emissions levels to those consistent with fair effort sharing. This would result in less stringent fair share emission reductions for countries that currently have high per capita emissions, compared to a case where the fair share calculations had been carried out several years prior (i.e. with a longer time horizon). In the default CERP approach used by the Civil Society Equity Review and in the present analysis, this is partially addressed by having the baseline and mitigation pathway start diverging in 2016, the year after the Paris Agreement was adopted, instead of moving the mitigation start date further into the future as time passes. This ensures that the potentially biasing effect is minimized.

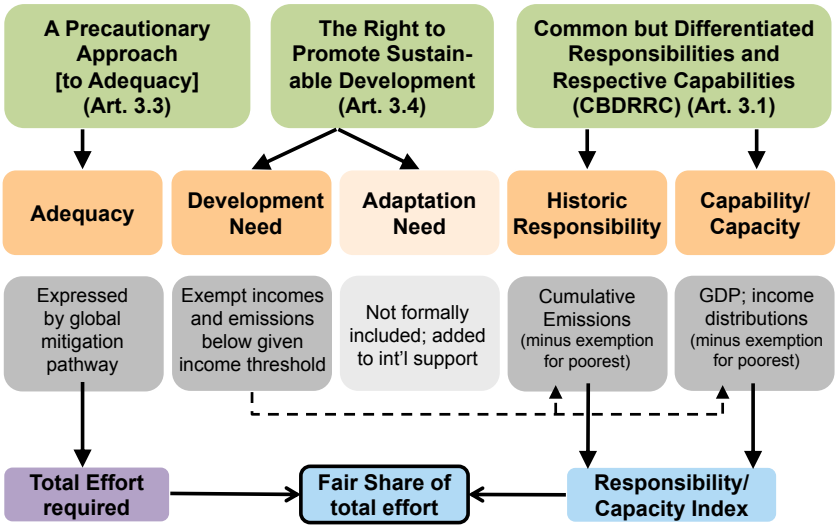
Box 1. The quantitative model of the Climate Equity Reference Framework

The fair shares calculations used here are based on the Climate Equity Reference Framework (CERf), a generalized effort-sharing framework that evolved from the earlier Greenhouse Development Rights (GDRs) framework.[24]

The figure shows the general structure and implementation of the CERf. Taking as a point of departure the equity principles of the United Nations Framework Convention on Climate Change[25] (green, indicating the relevant UNFCCC article in parenthesis) – (1.) precautionary approach, (2.) right to promote sustainable development and (3.) common but differentiated responsibilities and respective capabilities (CBDRRC) – the CERF conceptualizes these principles via intermediate concepts (orange), namely, for (1.) adequacy, for (2.) development and adaptation need and for (3.) historical responsibility for emissions and capability or capacity for implementing climate solutions.

Those intermediary concepts, in turn, are represented by indicators (grey) quantified via authoritative data sources. Specifically, adequacy is quantified via mitigation pathways drawn from the IPCC's scenario database.[26] Development need is quantified jointly with historical responsibility and capacity, via the different treatment of the incomes and emissions of

individuals at different levels of income (and consumption) when calculating a country's national historical responsibility and national capacity. The overall philosophy behind this approach is that incomes below a certain, user-defined, threshold are most appropriately prioritized for development and poverty eradication and therefore not available to be mobilized for climate solutions. And that, likewise, the survival emissions associated with consumption at the same low level of income ought to be treated differently from other emissions[27] and are therefore excluded from a nation's responsibility. For each of the world's countries, then, the total share of that entity of the total global responsibility and capacity is calculated (the Responsibility/Capacity Index), and used to calculate the entity's fair share of the total global mitigation effort as equal to its share of the global capacity and responsibility. More detail on the data sources used for the calculations is available[28] and the formulas of the quantitative model are given and explained elsewhere.[29]



Source: Reproduced from C. Holz, T. Athanasiou and S. Kartha. (2022). *France's Climate Fair Share.* Climate Equity Reference Project Working Paper Series, WP007. Accessed 12 July 2023. https://doi.org/10.5281/zenodo.2595502.

For the 'current emissions' bias, whereby countries with currently high emissions are allocated relatively more emissions in the near future on account of these, the CERP framework offers an option to partially address this via its implementation of 'luxury-capped baselines'.[30] With luxury-capped baselines, emissions associated with excessive consumption are not subject to global effort sharing but are the sole responsibility of the country where they occur, and only the remainder of each country's emissions are shared among all countries in accordance with the fair shares approach. In other words, the baselines of high-emitting countries are downward corrected for their luxury emissions, thus partially addressing the current emissions bias. However, this option is not typically utilized by groups using the CERP approach for their assessments, including the Civil Society Equity Review. For this reason, it is not used for the present analysis either.

2.2.3 Equal-Per-Capita-Consumption-CO2 (EPCCC) emissions

The EPCCC approach cannot be considered an equity-based benchmarking approach. Rather, it has been developed as a simple, single, global heuristic benchmark for contextualizing findings on carbon emissions inequality as well as for assessing NDC ambition. It is derived by dividing the (in this case, 2030) CO2 emissions under the global mitigation pathway by the projected world population in that year and uses the resulting globally uniform per capita emissions level as the benchmark for assessing NDC ambition. This is based on the ethical premise of the inherent equal worth of human beings and that each human has an equally sized claim on a globally shared scarce resource (the 'carbon budget'). However, this is an uncomplete ethical premise as it ignores the fact that countries, and indeed people, experience profound inequities with regards to past and current emissions levels, levels of development and poverty, access to sustainable development, and so on, and ignores the universally agreed equity principles of the UNFCCC and the Paris

Agreement of 'common but differentiated responsibilities and respective capabilities.' Ethicists as early as Aristotle have consistently observed that assigning equal shares to actors that are unequal in relevant dimensions (in this case, their capacity to address the climate crisis and face climate impacts) is, in fact, unjust.

Consequently, in previous publications that utilized the EPCCC benchmark, Oxfam highlighted that it does not consider this simple metric a 'fair' approach to sharing the global mitigation effort. This view is justified because the metric fails to take historical overuse (and the resultant economic benefit) into account, thus violating intergenerational equity considerations (under this metric, humans that lived in the past will have, on average, a much larger share of the globally shared scarce resource and humans living in the future can only be allowed to lay claim to a much smaller, or even no, share). Furthermore, the metric does not take any considerations of capacity (or capability) to act on the climate emergency into account, which is contrary to the UNFCCC principle of 'common but differentiated responsibilities and respective capabilities' and other ethical principles that suggest that in resourcing efforts toward a common goal, those who have more should be contributing more.

Box 2. Fair shares and the 1.5°C-compatible per capita level (the EPCCC benchmarking level)

It is vital to stress that achieving the 1.5°C-compatible per capita level does not reflect any country's 'fair share' of the global effort to address the climate crisis. After all, high-income countries and regions like the USA, EU and UK have benefited from centuries of carbon-intensive growth and have the greatest economic capacity to act.

For such countries, a 'fair share', in line with the analysis of the Civil Society Equity Review group, requires *both* deep domestic emissions reductions – *at a minimum* – to the 1.5°C-compatible per capita level, *and in addition* the provision of adequate, new and additional international climate finance to support low- and middle-income countries who require it to limit their emissions to the same level. Furthermore, given the worsening impacts of the climate crisis, a fair share for such countries also entails the provision of adequate financing for climate adaptation and to address climate-related loss and damage.

The fact that these countries are still not on track to reach the 1.5°C per capita level by 2030, *and* have still not delivered the minimal commitment to mobilize $100bn per year in international climate finance by 2020, is a double indictment of their moral and legal failure in view of the equity principle at the heart of the UNFCCC and its Paris Agreement.

Source: Reproduced from T. Gore. (2021). *Carbon Inequality in 2030: Per Capita Consumption Emissions and the 1.5°C Goal*. Institute for European Environmental Policy and Oxfam. Accessed 12 July 2023. https://policy-practice.oxfam.org/resources/carbon-inequality-in-2030-per-capita-consumption-emissions-and-the-15c-goal-621305; E. Ghosh, S. Kartha and A. Nazareth. (2022). *The Inequality-Emissions Link and What It Means for the 1.5°C Goal. SEI Methodological Note (Pre-Print)*. Stockholm Environment Institute. Accessed 12 July 2023. https://www.sei.org/wp-content/uploads/2022/01/220109a-burton-ghosh-inequality-report-2111a.pdf.

The metric can nonetheless still be useful, *if* one keeps in mind that 'developing' countries should and can only be expected to reach this level of per capita emissions with substantial climate finance and support provided by 'developed' countries, and that in 'developed' countries this level can only be considered sufficiently equitable if it is complemented with the provision of this finance and support.[2] As such, it can serve as a 'quick glance' ambition metric (but not equity metric) to assess whether countries are planning to engage in a sufficient level of domestic mitigation in line with 1.5°C pathways. Especially, it has been used as a globally uniform benchmark to contextualize current and future emissions of different income groups in different countries, thus helping to

[2] In this paper, the terms 'developed' and 'developing' countries are used because this is the terminology that is utilized in the UN Framework Convention on Climate Change, the Paris Agreement, and in UN climate change negotiations. The author acknowledges that these terms are not unproblematic and not uncontested. Where appropriate, the terms 'high-income' and 'middle-income' countries are also used and follow the specific classification of the World Bank. In the G20, Australia, Canada, the EU, France, Germany, Japan, Italy, Saudi Arabia, South Korea, the UK and the USA are high-income economies, the other G20 members are middle-income economies.

highlight different responsibilities for emissions and emissions reductions not only across countries, but across socioeconomic strata within countries.[31]

A unique and innovative feature of the EPCCC metric, which is the main reason for its inclusion in this paper, is its use of *consumption*-based emissions accounting. This is different from the standard, 'territorial' emissions accounting under the UNFCCC and elsewhere (and as used by the CAT and CERP approaches) in that consumption-based accounting assigns responsibility for the emissions associated with the production of energy, goods and services, and therefore the responsibility for their reduction, to the *consumers* of this energy and these goods and services, as opposed to the producers as in the default accounting. This is based on the view that consumption ultimately drives demand for energy, goods and services and is thus the ultimate cause of the release of the CO_2 emissions associated with their production. It therefore corrects for the effect where the production of goods and services consumed in high-consuming countries, and the emissions associated with their production, are outsourced to other countries. In practice, consumption emissions are calculated by subtracting from a country's territorial emissions those emissions that are embodied in its exports and adding the emissions embodied in its imports. To be able to assess the ambition of NDCs (which are based on the default production, or territorial, emissions accounting) against the EPCCC benchmark, each NDC therefore needs to be adjusted to reflect the emissions from *consumption* in the country under policies and measures consistent with the NDC. This NDC quantification was carried out by the Stockholm Environment Institute.[32]

The EPCCC metric only considers CO_2 emissions from energy and industry. It does not consider non-CO_2 GHGs, such as methane, nitrous oxide, or fluorinated gases, nor does it look at CO_2 emissions from other sectors, most importantly, from land use, land use change, and forestry (LULUCF). This limitation is due to the lack of open-source data for non-CO_2 emissions embodied in imported and exported goods and services, which is required to calculate consumption-based emissions. The limitation must be kept in mind when using the EPCCC metric, since for several G20 countries a large fraction of their overall GHG emissions are from non-CO_2 GHGs,[33] and deep mitigation in non-CO_2 GHGs is also required for overall alignment with 1.5°C-consistent mitigation pathways.

In general, countries with larger historical per capita emissions tend to fare worse when assessed against this metric than countries with smaller historical per capita emissions, simply because of a larger distance of historical emissions from the common benchmark. In extreme cases, countries with very low historical emissions would get a 'pass' grade even in scenarios where they do not undertake any mitigation action, while historically high emitters would need to reduce their emissions by 80% or more to get below the benchmark.

In addition to the shortcomings described above, the fact that mitigation targets in NDCs are expressed in terms of territorial emissions accounting, as opposed to the consumption-based accounting assumed by the EPCCC approach, also somewhat limits the applicability of the EPCCC approach for assessing NDCs. The modelling required to derive consumption-based emissions levels from the measures and policies embodied by the NDC necessarily utilizes exogenous assumptions (e.g. regarding GDP growth, income distributions, the persistence of consumption trade pattern)[34] that can strongly influence the results of this modelling,[35] thus potentially introducing bias.

At the time of writing, the EPCCC approach has not been published in the peer-reviewed literature.

2.3 DIFFERENCES AND COMMONALITIES ACROSS THE THREE BENCHMARKING APPROACHES

Since this paper aims to compare the results from the selected ambition and/or equity assessment approaches, it is important to highlight the ways in which the approaches are similar or different, especially if the differences substantially influence the respective results. Likewise, it is important to understand common features and limitations of the approaches in order to appropriately interpret the results.

2.3.1 Commonalities

None of the three approaches includes emissions from LULUCF, a category that includes emissions from deforestation. This is particularly relevant for the assessment of countries, such as Brazil and Indonesia, where deforestation emissions represent the overwhelming part of the country's emissions profile. Limiting the NDC assessment to sectors other than LULUCF means that it cannot reveal whether these countries are pledging to do enough in the sector that matters most with regards to their overall contribution to mitigation. Moreover, this can also introduce substantial uncertainty in the quantification of the mitigation impact of the NDC in non-LULUCF sectors. This occurs when mitigation targets in NDCs are articulated as 'economy-wide' – covering both LULUCF and non-LULUCF emissions – but it is unclear how much of the overall reduction is expected to occur in the LULUCF sector and how much is expected to occur elsewhere. Therefore, the results of these assessments must be interpreted with a great deal of caution in those cases.

None of the approaches formally take into account climate finance provided by high-income countries as part of their overall contribution and received by low- and middle-income countries to deepen their mitigation efforts beyond what they would be able to do without this finance. However, all three approaches do acknowledge that this would be a critical element of a complete assessment.[36] The CAT approach includes a climate finance assessment in principle, but in practice it is only carried out for a small subset of countries and even in these cases does not have an impact on its results due to the way the individual pillars of the CAT assessment are combined into the overall hybrid assessment.

Both the CAT effort sharing and CERP approaches ask, 'How much mitigation (and/or resources for mitigation) can a country fairly be expected to contribute to the global effort?' under certain, different conceptualizations of fairness. This does not necessarily mean that these countries are expected to undertake the entirety of this mitigation within their own borders, or that this is the only mitigation that is undertaken within their countries. It is merely the amount that they are expected to contribute with their own resources. Typically, for high-income countries, some of the mitigation that is carried out with the country's resources takes place in other (low- and middle-income countries) because high-income countries have fair share contributions that are too large to be implemented solely within their borders. The reverse is often the case in low- and middle-income countries, where actual emissions reductions have to be deeper than what can be fairly expected of these countries to implement with their own resources, hence being typically thought of as conditional upon the receipt of finance and support from high-income countries.[37]

This is important to keep in mind when interpreting results because it means, for high-income countries, that a complete assessment of their pledges against their mitigation fair share would need to include both their domestic mitigation pledge *and* their pledges for finance and support for mitigation elsewhere. For low- and certain middle-income countries, on the other hand, merely contrasting the mitigation fair share with their domestic mitigation pledge does not take into account the fact that, unfair as this might be, low- and certain middle-income countries will need to undertake more mitigation than their fair share, conditional on climate finance and support.

In contrast, in the EPCCC approach, the focus of the benchmark is the physical domestic emissions level of emissions within the country, since it is acknowledged that expecting this stringent level of domestic mitigation from many middle- and especially low-income countries would be unfair in the absence of climate finance and support. In contrast, for high-income countries merely limiting domestic emissions to the benchmark level would not constitute an overall fair contribution without, at the same time, also providing substantial climate finance and support for mitigation elsewhere (see Box 2).

2.3.2 Differences

The perhaps most important difference, other than those already discussed, relates to how the rating categories (as expressed by the shade of the coloured bars and their labels in Figures 3 to 8) are scaled relative to the benchmark.

In the CAT effort sharing assessment, the ranges of emissions associated with the different rating categories have different scales for each country, while they are constant (in terms of tCO_2/capita or tCO_2eq/capita) for the other approaches. The ranges are also much narrower for low- and middle-income countries than for high-income countries. For example, the width of the narrowest single segment of the effort sharing range for the USA is wider than the entire effort sharing range for India: the distance from the lower to the upper end of the 'almost sufficient' segment of the effort sharing range for the USA is 2.4 tCO_2eq/cap (from 5.3 to 7.7 tCO_2eq/cap) while, for India, the *entire* effort sharing range – from '1.5°C consistent' to 'critically insufficient' – is only 1.5 tCO_2eq/cap (from 2.3 to 3.8 tCO_2eq/cap), compared to 13.1 tCO_2eq/cap (5.3 to 18.4) for the USA. In other words, while a hypothetical Indian NDC that falls short of the '1.5°C consistent' CAT benchmark by, say, 1.6 tCO_2eq/cap would receive the worst 'critically insufficient' label, a hypothetical US NDC that falls short of the benchmark by the exact same amount of 1.6 tCO_2eq/cap would receive CAT's second best 'almost sufficient' assessment.

In contrast, in the EPCCC and CERP assessments, as used in this report, a fixed amount of excess of NDC-implied per capita emissions in 2030 above the benchmark level is utilized to define the benchmark ranges to apply rating labels.

As already discussed, the CAT and CERP approaches also differ in how they consider equity in their benchmark generation. For CAT, a large sample of quantifications from the peer-reviewed effort sharing literature (as well as some proprietary CAT quantifications) representing a wide range of different perspectives on effort sharing (including some that are not generally considered equitable) are combined into a single 'fair shares range' which is then utilized as the benchmark against which to assess NDCs. The IPCC's fifth assessment report categorized the different perspectives on effort sharing into a non-exhaustive taxonomy of five broad categories that reflect equity principles that can be considered when deciding what is fair: 1. Responsibility; 2. Capability; 3. Equality; 4. Responsibility/Capability/Need; 5. Equal Cumulative Per Capita Emissions (plus the 'Staged Approaches' category, which combine two or more of these perspectives).[38]

The CAT's approach to generating effort sharing benchmarks from the effort sharing literature includes data points from studies in all six of these categories. In contrast, the CERP approach falls into the Responsibility/Capability/Need category and does not include benchmarks from the other categories (except insofar as responsibility and capability are reflected in the Responsibility/Capability/Need category's integrated treatment of these perspectives). Since the Equality, Staged Approaches and, to a lesser degree, Responsibility, categories tend to favour wealthier and higher-emitting countries, the CAT's inclusion of these categories tends to result in less stringent benchmarks for those countries, compared to the CERP benchmarks.

Further, since there is no official resource that quantifies the emissions level that would result from the implementation of a country's NDC, this quantification was done by the respective authors of each approach, resulting overall in slight (though at times substantial) differences in results. The main reasons for the differences are uncertainty about the projected baselines and GDP (for baseline-relative or intensity-based NDC targets); population projections (for the conversion of absolute values to per capita values); the split between effort in LULUCF and other sectors when an economy-wide target is pledged but analysis excludes LULUCF; and the split between CO_2 from energy and industry and other sectors and gases where the analysis is for CO_2 from energy and industry only (in the case of EPCCC).

As detailed above, EPCCC utilizes consumption-based emissions accounting for the NDC and emissions benchmark, while CAT and CERP use territorial accounting. Furthermore, while all three approaches focus on benchmarks consistent with limiting global temperature increase to 1.5°C, the specific mitigation pathways and global ambition metrics they use differ somewhat.

Finally, owing to the general structure of the approach, the EPCCC benchmark can be a positive value, while CERP and CAT can have negative benchmark levels, which highlights the fact that in both cases provision of climate finance is crucial for high-income countries to fully meet their benchmarks (since otherwise, negative benchmarks could not be satisfied).

3 ASSESSMENTS OF G20 COUNTRIES' AMBITION

3.1 CAT EFFORT SHARING ASSESSMENT

The most striking difference between the CAT approach and the other two approaches is that it rates the high-income G20 countries more favourably. All the G7 countries that are covered by the CAT analysis receive the highest rating given to any G20 country in the effort sharing assessment ('insufficient'), while only three of the 'developing' country members of the G20 (Brazil, India and South Africa) receive this same rating, with most 'developing' or 'economies-in-transition' countries receiving a 'highly insufficient' or 'critically insufficient' rating.[39]

In terms of the excess of NDC-implied emissions targets over the CAT '1.5°C consistent' effort sharing benchmark, the largest difference is 10 tCO_2eq/capita in the case of Russia, while South Africa, Brazil and India have the smallest excesses, of 0.3, 0.5 and 0.7 tCO_2eq per capita, respectively. However, notably no G20 country has submitted an NDC with a mitigation target that is consistent with CAT's '1.5°C consistent' benchmark. In terms of the effort sharing assessment, none of the G20 NDCs has even received the second-highest 'almost sufficient' rating (though the UK achieves this rating under the CAT hybrid assessment when other ambition metrics are included). This clearly indicates that all G20 countries need to urgently enhance their NDC mitigation pledges and associated policies and measures as well as, in the case of the higher-income G20 countries, steeply ramp up the provision of international climate finance to allow lower-income countries to undertake deeper cuts than otherwise possible.

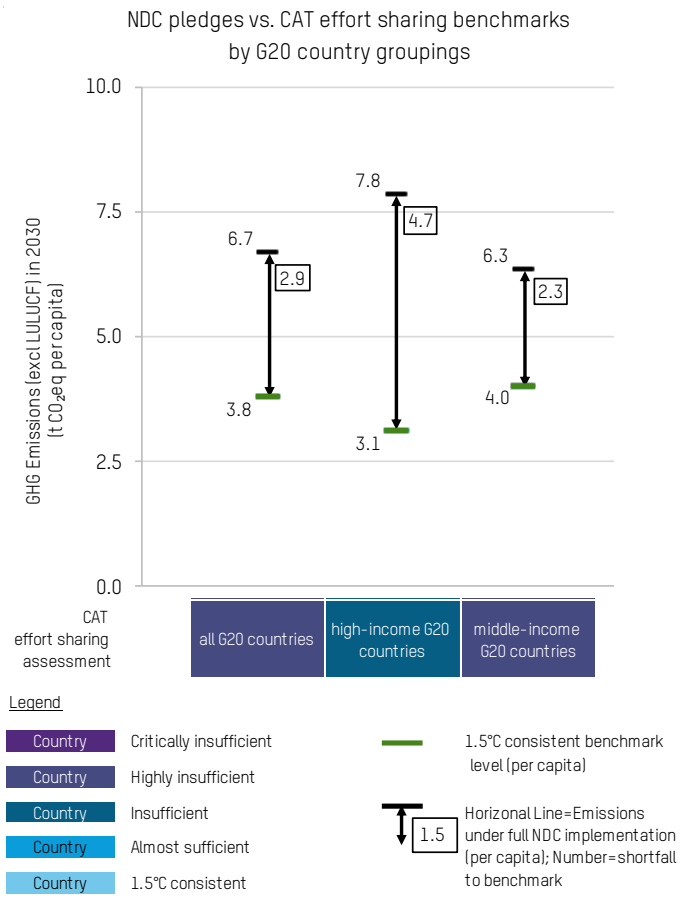
On average,[40] the NDCs of all G20 countries combined (Figure 3) imply a 6.7 tCO_2eq per capita emissions level in 2030, which is nearly twice the 1.5°C-consistent CAT benchmark level of 3.8 tCO_2eq on average, or a shortfall of 2.9 tCO_2eq per capita. For the high-income G20 countries, the 1.5°C-consistent benchmark level is, on average, 3.1 tCO_2eq, while their NDCs imply a per capita emissions level as high as 7.8 tCO_2eq in 2030, or a shortfall of 4.7 tCO_2eq per capita on average. The shortfall of the middle-income G20 countries relative to the 1.5°C benchmark (4.0 tCO_2eq/cap) is much smaller at 2.3 tCO_2eq/cap.

It is also worth noting that one effect of the CAT approach to benchmarking is that countries with only a relatively small absolute excess of their pledged target emissions over their benchmark (e.g. Indonesia, Argentina and Mexico) can receive lower ratings than other countries with much higher absolute excess (e.g. Germany, USA, UK, EU and Australia) because their effort sharing benchmark is so comparatively small, and thus their effort sharing range comparatively narrow, so that even a small amount of additional excess can place them in the lower rating category. For example, for Germany, the difference between the best and second-best rating category is 1.9 tCO_2eq per capita, while for India, the entire effort sharing range, the difference between the best and very worst categories, is only 1.5 tCO_2eq per capita.

This is also the main reason why middle-income G20 countries would, collectively, nevertheless receive the lower 'highly insufficient' rating, compared to the high-income G20 countries' better 'insufficient' rating, despite the latter's shortfall between the 1.5°C CAT benchmark and NDC being more than double in absolute per capita terms. Given the much larger population and overall emissions of the middle-income G20 countries (accounting for 80% of the population of the G20), this would result in the G20's CAT rating overall being 'highly insufficient' as well.

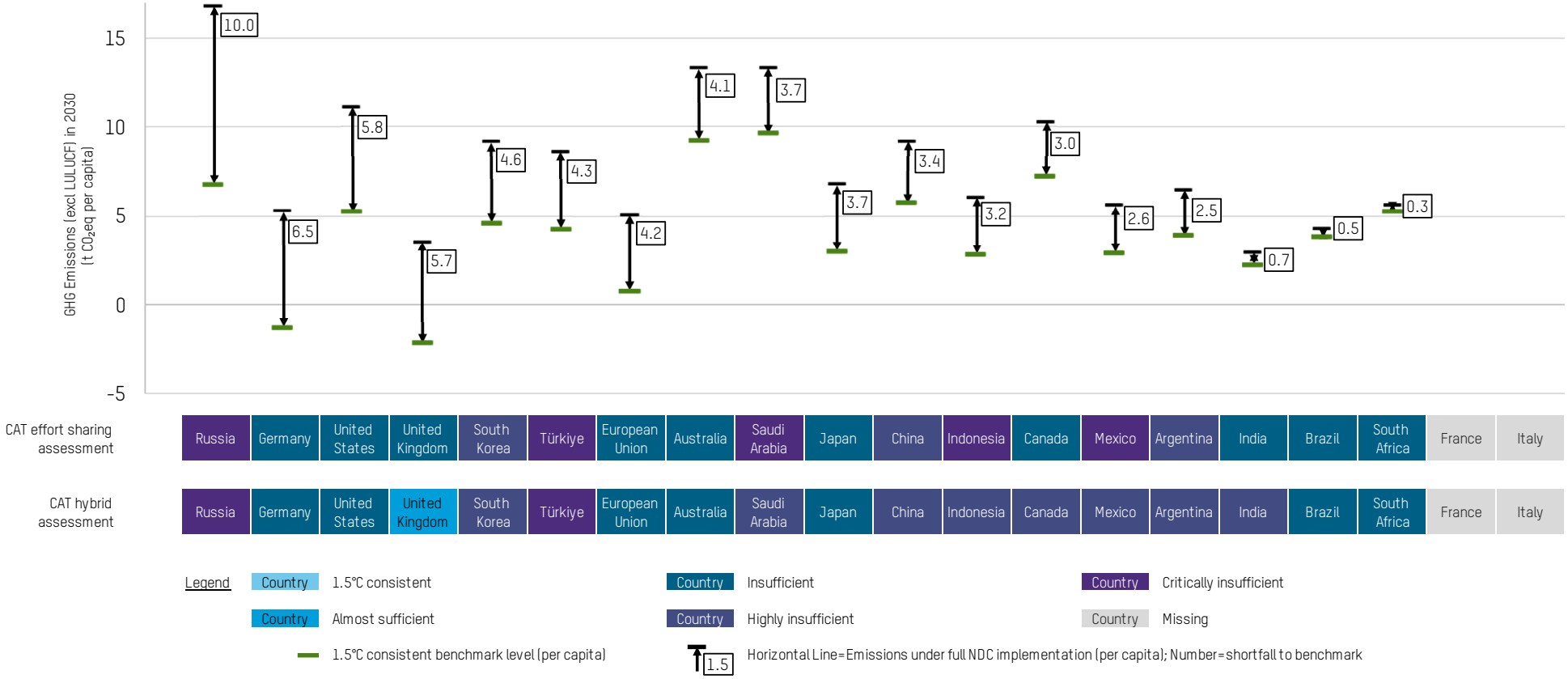
The CAT assessment also does not change very much, in the case of the G20 countries, between its effort sharing assessment and its new hybrid ambition metric. A few countries (Indonesia, Mexico, Saudi Arabia and the UK) slightly improve their rating when ambition metrics other than effort sharing are considered, and only two countries (Canada and India) see their rating decline. For all other countries, the rating remains the same.

Figure 3. Summary of results of the CAT effort sharing assessment, aggregated for G20, high-income G20 and middle-income G20 countries



Source: Author's composition, based on data from CAT. (2023). *Country Assessments (May 2023)*. Climate Action Tracker. Accessed 12 July 2023. https://climateactiontracker.org/countries/
The CAT does not directly provide ratings for aggregates of countries. The CAT assessment ratings were obtained by summing the NDC emissions for each aggregated group and summing the CAT-provided thresholds for each of the CAT rating categories to assign the appropriate CAT rating to each group of countries. Green horizontal dashes show the 1.5°C-consistent per capita emissions levels in 2030 (benchmark) for each country aggregation. The horizontal black dash shows the per capita emissions level in 2030 that would result from the implementation of the NDCs of each country in the group. The arrow between the green and black dashes shows the shortfall between benchmarks and NDCs, and the number label box shows the size of this shortfall in tons of CO_2eq per capita. Blue country group label boxes are colour-coded to reflect the assessment labels; black font and lighter shades for NDCs that are more, white font and darker shades for NDCs that are less, aligned with benchmarks. In cases where an NDC expresses a mitigation pledge as a range, the more ambitious end of that range is plotted here.

Figure 4. Results of the CAT effort sharing assessment



Source: Author's composition, based on data from CAT. (2023). *Country Assessments (May 2023)*. Climate Action Tracker. Accessed 12 July 2023. https://climateactiontracker.org/countries/.
In cases where an NDC expresses a mitigation pledge as a range, the more ambitious end of that range is plotted here.

3.2 CERP 1.5°C FAIR SHARES ASSESSMENT

In the results of the CERP 1.5°C fair shares assessment (Figure 5), all the 'developed' G20 countries are in the half of the countries with the biggest shortfalls in relation to the 1.5°C fair share benchmark. For all the 'developed' G20 countries, except Russia, that shortfall is over 10 tCO_2eq per capita, reaching as high as 24.6 tCO_2eq/capita in the case of the USA.

The shortfall against the benchmark is less than 10 tCO_2eq/capita for each of the 'developing' country G20 members, in most cases substantially so. The G20 countries closest to their 1.5°C fair share benchmark are Argentina, India, China and South Africa, coming within 0.6 and 0.1 tCO_2eq/capita of the benchmark, respectively, for Argentina and India, meeting it precisely (China), or even (South Africa) potentially surpassing it by 0.4 tCO_2eq/capita (if the more stringent end of South Africa's NDC range is implemented).

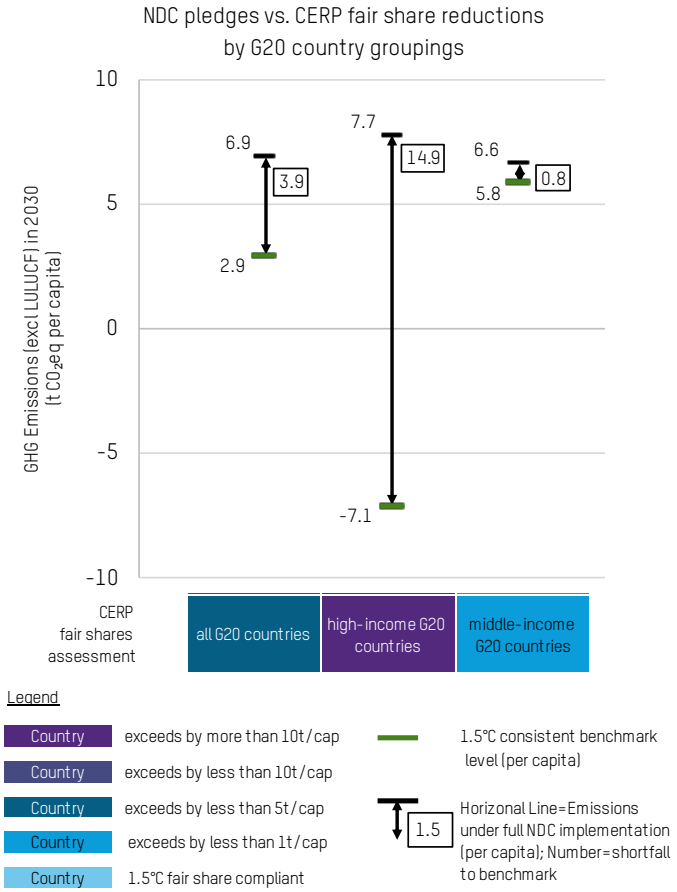
On average, if all G20 countries were to fully implement their NDCs, this would imply a 6.9 tCO_2eq per capita emissions level in 2030, which is more than twice the CERP fair shares 1.5°C-consistent benchmark level of 2.9 tCO_2eq, or a 3.9 tCO_2eq shortfall between NDC pledge and benchmark level. However, it is also very instructive to separately consider high-income G20 countries versus middle-income G20 countries. For the high-income countries, the 1.5°C consistent CERP fair shares benchmark level is, on average, -7.1 tCO_2eq, and given the emissions level in their NDCs, their shortfall is just under 15 tCO_2eq on average, compared to a much smaller shortfall of 0.8 tCO_2eq for the middle-income countries (Figure 6).

Figures 5 and 6 also demonstrate an important result of the CERP approach: for high-income countries, especially those that have a long history of high emissions and command large amounts of material resources, the 1.5°C fair shares benchmark is a negative number, in many cases (USA, UK, Japan, Germany and France) substantially so (note that the CAT's 1.5°C effort sharing benchmark for the UK and Germany is likewise negative). This stems from the basic premise that each country should contribute to the global mitigation effort commensurate with their historical responsibility and their capacity to act (while excluding the emissions and income of the poorest people in all countries from both metrics) without capping that level of contribution arbitrarily, for example at a country's level of emissions (which would imply a minimum benchmark level of 0 tCO_2eq/cap). As a result, many high-income countries have fair share benchmarks that they cannot possibly achieve by domestic emissions reductions. Inversely, many middle-income and especially low-income countries' fair shares are often lower or much lower than the domestic mitigation that needs to occur in these countries under the global 1.5°C mitigation pathway. This conundrum can only be resolved fairly by the provision of substantial climate finance by high-income countries to lower-income countries, commensurate with the amounts of high-income countries' fair shares that cannot be implemented through domestic mitigation, to enable lower-income countries to mitigate deeper than they could with their own means alone, and than they could be fairly asked to without this finance.

However, the present analysis cannot take account of these dynamics because 'developed' countries have not been willing to determine the amount of climate finance they are going to provide ahead of time, so how much climate finance will flow from each 'developed' country in 2030 is currently unknown. Given this, it is not possible to assess the additional mitigation that 'developing' countries would be able to undertake with this finance.

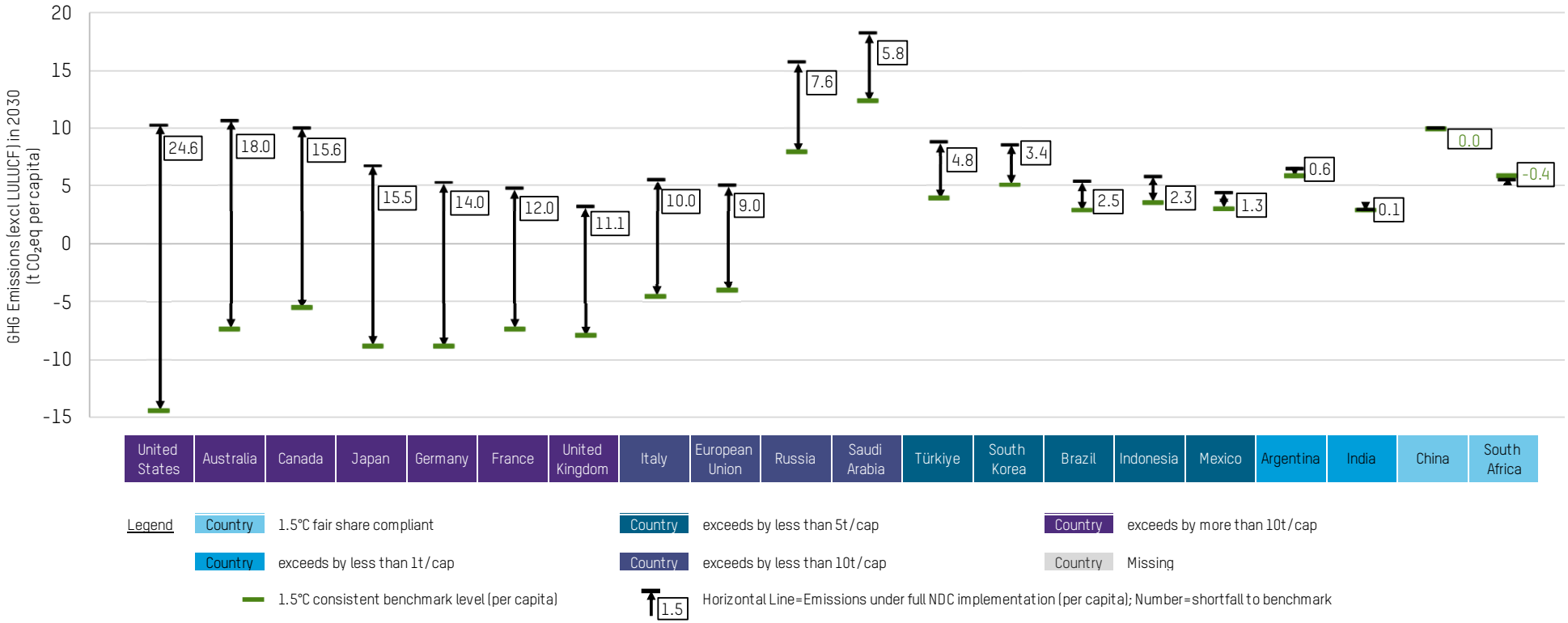
For the G20 countries, the CERP analysis confirms the picture that emerged from the other approaches: that high-income G20 countries in particular not only have to deepen their domestic mitigation ambition to make them consistent with 1.5°C compliant global mitigation, but also steeply increase their contributions to international climate finance. Lower-income country G20 members for the most part also have to increase their mitigation ambition, but many can justly demand that climate finance is made available to them to finance these deeper emission cuts.

Figure 5. Summary of results of the CERP fair shares assessment, aggregated for G20, high-income G20 and middle-income G20 countries



Source: Author's composition, based on data from the Climate Equity Reference Calculator. C. Holz, E. Kemp-Benedict, T. Athanasiou and S. Kartha. (2019). 'The Climate Equity Reference Calculator'. *Journal of Open Source Software*, 4(35), 1273. https://doi.org/10.21105/joss.01273; E. Kemp-Benedict, C. Holz, T. Athanasiou, S. Kartha and P. Baer. (2022). *The Climate Equity Reference Calculator*. EcoEquity and Stockholm Environment Institute. Accessed 12 July 2023. https://calculator.climateequityreference.org
Green horizontal dashes show the 1.5°C-consistent per capita emissions levels in 2030 (benchmark) for each country aggregation. The horizontal black dash shows the per capita emissions level in 2030 that would result from the implementation of the NDCs of each country in the group. The arrow between the green and black dashes shows the shortfall between benchmarks and NDCs, and the number label box shows the size of this shortfall in tons of CO_2eq per capita. Blue country group label boxes are colour-coded to reflect the assessment labels; black font and lighter shades for NDCs that are more, white font and darker shades for NDCs that are less, aligned with benchmarks.

Figure 6. Results of the CERP fair shares assessment



Source: Author's composition, based on data from the Climate Equity Reference Calculator;[41] NDC quantifications for Argentina and Germany from CAT;[42] NDC quantifications for France and Italy from Climate Resource .[43] In cases where an NDC expresses a mitigation pledge as a range, the more ambitious end of that range is plotted here.

3.3 EPCCC 1.5°C BENCHMARK ASSESSMENT

On average, G20 per capita consumption CO_2 emissions will be 5.1 tCO_2/cap in 2030 if all G20 NDCs are fully implemented as pledged. This is more than double the EPCCC's 1.5°C compatible global equal per capita figure (2.3 tCO_2/cap). Comparing G20 NDCs to the NDCs of all countries, the G20's 5.1 tCO_2/cap is also substantially larger than the global average consumption CO_2 emissions of 4.5 tCO_2/cap that would result if all countries fully implemented their NDCs.[44]

This shortfall of pledges compared to the EPCCC benchmark is even more pronounced in Russia and the USA; in both cases the full implementation of the NDC would still result in consumption CO_2 emissions more than four times the global average benchmark, with an excess of emissions of as high as 7.2 and 7.1 tCO_2 per person, respectively.

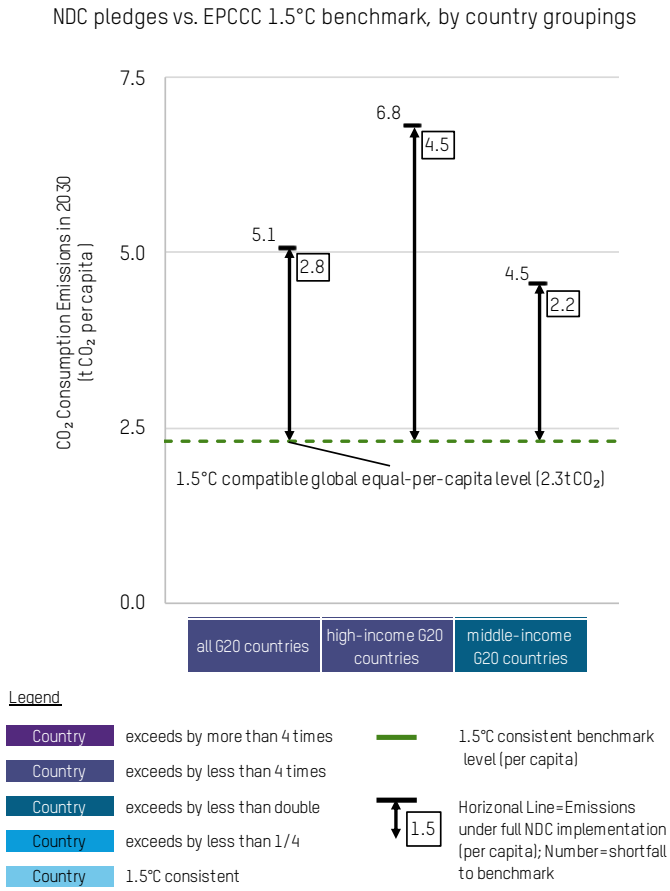
Further, in the cases of Saudi Arabia, South Korea, Australia, Türkiye, China, Canada, Japan and Germany, the per capita consumption CO_2 emissions implied by their full NDC implementation is equivalent to somewhere between two and four times the global equal-per-capita benchmark. The excess emissions above the global equal per capita benchmark range from 4.1 to 6.9 tCO_2 per capita in these countries.

The EU, Mexico, Italy, Indonesia, UK, France and Argentina NDCs have mitigation implications that would leave these countries with less than double the global equal per capita benchmark (with excesses ranging from 0.9 to 2.3 tCO_2 per capita).

Only South Africa, Brazil and India get close to (or exceed) the benchmark. For India and Brazil, the pledged level of ambition would be enough to limit per capita consumption emissions to below the benchmark, while for South Africa, the NDC-implied emissions levels are only about one-quarter above the benchmark level.

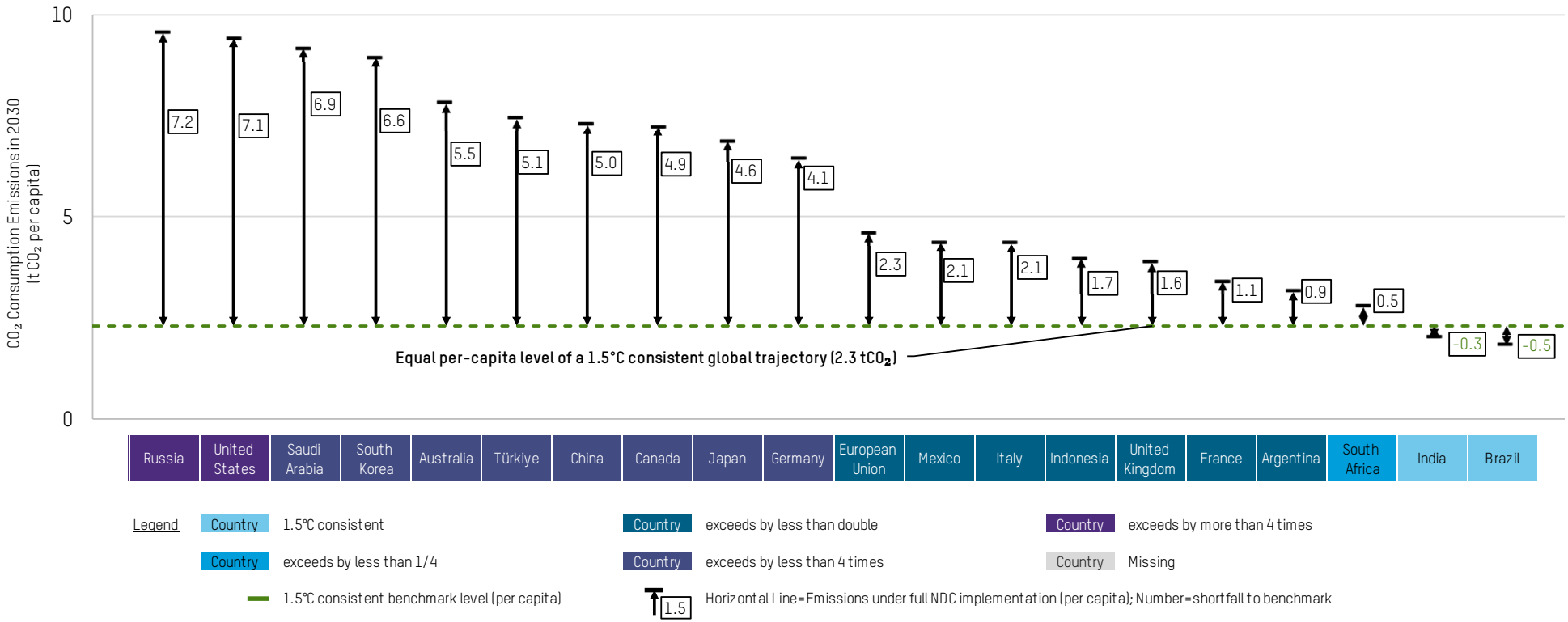
As noted above, the assessments of countries with a large share of LULUCF/deforestation emissions, such as Brazil and Indonesia, should be used cautiously as these assessments do not show these emissions.

Figure 7. Summary of results of the EPCCC approach, aggregated for G20, high-income G20 and middle-income G20 countries



Source: Author's composition, based on data from Oxfam[45] and SEI.[46] Green horizontal dashes show the 1.5°C-consistent per capita emissions levels in 2030 (benchmark) for each country aggregation. The horizontal black dash shows the per capita emissions level in 2030 that would result from the implementation of the NDCs of each country in the group. The arrow between the green and black dashes shows the shortfall between benchmarks and NDCs, and the number label box shows the size of this shortfall in tons of CO2 per capita. Blue country group label boxes are colour-coded to reflect the assessment labels; black font and lighter shades for NDCs that are more, white font and darker shades for NDCs that are less, aligned with benchmarks.

Figure 8. Results of the EPCCC approach



Source: Author's composition, based on data from Oxfam[47] and SEI.[48]

4 CONCLUSIONS AND IMPLICATIONS

Overall, high-income countries have the primary historic responsibility and technological capability and financial capacity to mitigate the climate crisis. As the group of largest economies, and biggest emitters, in the world, a successful solution to the climate crisis can only be imagined when the G20 are leading on emission reductions and, for the wealthier G20 countries, on the provision of climate finance and support for other countries' mitigation actions.

However, this paper's assessment of the ambition and fairness of G20's emission reduction targets in the NDCs shows that collectively the G20 are failing to achieve their fair share of ambitious global mitigation and almost all of the G20 countries are also failing individually under most metrics considered here. Since this paper used three different approaches (two of which utilize different views on the fairness of sharing responsibility for emissions reductions), and all three approaches came to broadly the same conclusions, these can be considered fairly robust to differences of perspectives on fairness and ambition. Under none of these assessment approaches do G20 NDCs collectively, or the NDCs of high-income G20 countries individually, represent the level of ambition required for a 1.5°C global mitigation pathway.

The shortfall between the G20's collective NDCs and the fairness and/or ambition benchmarks of the three approaches ranges from 2.8 tCO_2 per capita (EPCCC) to 2.9 tCO_2eq per capita (CAT) and 3.9 tCO_2eq per capita (CERP) in 2030 (Figures 3, 5 and 7). Given the projected population of the G20 of 5.1 billion people in 2030, this would translate to an overall absolute excess of emissions of 14.1bn tons of CO_2 (EPCCC) to 14.6bn tons of CO_2eq (CAT) and 20.2bn tons of CO_2eq (CERP), just from G20 countries alone. Contrasting these figures with the global shortfall of 20–23bn tons of CO_2eq between the NDCs of all countries and a 1.5°C-consistent pathway, as calculated by the UNEP Emissions Gap Report,[49] clearly shows that G20 countries have to play a central role for bringing the world in line with limiting global heating to 1.5°C by increasing their mitigation ambition.

Looking at the results for G20 countries in a more nuanced and differentiated fashion, even though all the G20 countries are among the largest economies in the world, there is a large degree of inequality between these countries. There are also inequalities in terms of wealth, per capita income levels, poverty rates and GHG emissions. Across all the assessment approaches used here, the high-income G20 countries' shortfalls vis-à-vis their 1.5°C consistent benchmarks are much, or very much, larger than those of middle-income G20 countries, ranging from about twice as large (CAT and EPCCC) to 18 times as large (CERP).

In high-income countries such as the USA and Australia, for example, the emissions levels that would result from implementing the pledged reductions are still far higher than what their fair share would allow: to meet their fair share benchmark under the CERP framework, they would have to enhance their NDC targets to reduce an additional 240% or 170% of their current NDC target emissions level, respectively. Likewise, under the CAT effort sharing assessment, Germany and the UK would need to further reduce their NDC target emissions by 160% and 124%, respectively, and Russia by 60%, to receive the '1.5°C compatible' rating.

These results – reductions well in excess of 100% – are typical results for 2030 for high-income countries from effort sharing approaches that foreground equity. Thus, even if these countries reduce their domestic emissions to zero by 2030, they would still fall short of these fair share benchmarks. This in turn means that for them to meet their fair share of global mitigation, they would have to provide substantial amounts of climate finance and technological and other support, in order to facilitate further emissions reductions in other countries at a scale that corresponds to the remaining shortfall relative to the fair share. Ideally, assessments of high-income countries' contributions against their mitigation fair share would include their domestic mitigation pledge *and* their pledges, if available, for climate finance and support. However, since high-income countries have long refused, and continue to refuse, to make commitments at the UNFCCC about the finance and support they will provide in the future (beyond a very short timeframe of a few years), such complete assessments remain impossible.

Middle-income G20 economies such as Indonesia, South Africa, Brazil, China and Mexico have lower historic responsibilities for the climate crisis and less available financial capacity to address it, but nevertheless also need to undertake substantial emissions reduction targets if the world is to limit global heating to 1.5°C. This analysis shows that middle-income G20 countries collectively, as well as many individually, are also failing to achieve their fair and/or ambitious share of global emissions targets; this needs to be addressed by countries adopting emissions reductions targets that are at least consistent with the benchmarks discussed here. Middle- and low-income countries must also be willing to implement emissions reductions that are deeper than their fair share would indicate, for 1.5°C-consistent global mitigation to remain possible. However, as it would be unjust to expect these countries to implement deeper cuts with their own resources, these would need to be facilitated by climate finance and support from high-income countries.

Based on this paper's overall approach, it is clear that all G20 countries need to enhance the ambition of their mitigation efforts. This is significant, because the three assessment methodologies follow substantially different approaches for assessing the ambition and/or fairness of countries' mitigation pledges, but this overall conclusion holds. Collectively, countries' mitigation targets are so far from the required level of ambition that increased domestic mitigation ambition and enhanced international cooperation is needed in every country. For the high-income G20 countries, in addition to enhancing domestic targets, this means significantly ramping up climate finance and other cooperation and support, so that middle-income G20 countries, as well as other middle- and low-income countries, can reduce their emissions even further than they could be fairly expected to, or would be practically able to, with their own resources alone.

These insights are important now as the Global Stocktake will be finalised by the end of 2023. Since the Global Stocktake aims to guide countries in enhancing the ambition of their own climate action as well as, for 'developed' countries, ramp up their provision of international climate finance and cooperation, this analysis can help identify which countries need to enhance their action and support the most, and by how much.

The continued failure of G20 countries to meet their ambitious and/or fair shares of global emissions reduction target is deepening the climate crisis. This not only has devastating consequences for people's lives but is also deeply unjust as it is low-income communities and marginalized social groups that suffer the brunt of climate inaction. There is still time to prevent runaway climate change. G20 countries, as well as the rest of the world, have much to gain from increasing the ambition and equity of climate action, though if mitigation ambition, including the provision of climate finance, is not enhanced in the next few years, the remaining 1.5°C carbon budget will have been used up and the window to limit global heating to 1.5°C will have closed. The time to do so is now.

NOTES

[1] This assessment is based on countries' explicit commitments under the Paris Agreement to pursue efforts to ensure global average temperature increase is limited to 1.5°C. This metric is a useful accountability tool but it is important to note that countries should not treat 1.5°C as a floor for climate ambition, particularly over the long term. The current level of global heating, around 1.1°C–1.3°C, is already deeply unsafe for many communities across the globe, violating their human rights to life, food, water, housing and many other rights. To abide by their commitments under international human rights law to protect these rights, governments should in fact take steps to limit greenhouse gases to a safe level. Oxfam's position is that a safe level for the concentration of carbon dioxide (CO_2) in the atmosphere is 350 parts per million (ppm), down from the current level of 419 ppm. See, for example, a recent submission to the European Court of Human Rights setting out the scientific analysis. Our Children's Trust and Oxfam. (2022). *Intervention in Verein KlimaSeniorinnen Schweiz and Others v. Switzerland, Carême v. France, and Duarte Agostinho and Others v. Portugal and 32 Others*. European Court of Human Rights. Accessed 12 July 2023. https://ourchildrenstrust.org/s/20221205-ECtHR-Interventions-FINAL.pdf

[2] United Nations. (20 March 2023). *Secretary-General calls on states to tackle climate change 'time bomb' through new solidarity pact, acceleration agenda, at launch of Intergovernmental Panel Report*. Press release. Accessed 12 July 2023. https://press.un.org/en/2023/sgsm21730.doc.htm

[3] IPCC. (2018). *Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. Intergovernmental Panel on Climate Change. Accessed 12 July 2023. http://www.ipcc.ch/report/sr15/

[4] Ibid.

[5] UNFCCC. (2022). *Nationally Determined Contributions Under the Paris Agreement. Synthesis Report by the Secretariat. 26 October 2022*. Bonn: UNFCCC. Accessed 12 July 2023. https://unfccc.int/ndc-synthesis-report-2022

[6] UNFCCC. (2015). *Paris Agreement*. Article 14. Geneva: United Nations Office. Accessed 12 July 2023. http://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf

[7] tCO_2eq/cap means tons of carbon dioxide equivalent per capita. Carbon dioxide equivalent (CO_2eq) is a unit of measurement that is used to measure different greenhouse gases in a common unit. For any given quantity and type of a greenhouse gas (or a mix of several greenhouse gases), CO_2eq signifies the amount of CO_2 that would have the equivalent global warming effect over a certain period of time as the given quantity of the given type (or mix) of other greenhouse gases.

[8] UN. (2019). *World Population Prospects: The 2019 Revision. (Medium Variant Projections)*. New York: United Nations Department of Economic and Social Affairs. Population Division. Accessed 12 July 2023. https://population.un.org/wpp/DVD

[9] The broader effort sharing literature is concerned with how to share the global effort of climate action (typically focused on or limited to mitigation) among the world's countries. Typically, though not always, this effort sharing is done following some interpretation of 'fairness'. However, some authors include effort sharing approaches that they themselves characterize as unfair, for example for comparison with other approaches; in other cases, authors propose effort sharing approaches with objectives other than fairness, for example, effectiveness; in others, authors propose approaches as fair that are based on principles that are broadly agreed to be unfair. A subset of this literature focuses on comparing countries' mitigation pledges (and/or policies or action) with the effort that the countries should be undertaking based on the effort sharing approach taken by a given study (like the present paper). Section 4.2.2.7 of the Working Group III contribution to the IPCC Sixth Assessment Report provides a good summary of this subset, while Section 4.5 gives an overview of the broader effort sharing literature. See IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change*. Intergovernmental Panel on Climate Change. Accessed 12 July 2023. https://www.ipcc.ch/report/ar6/wg3/

[10] See, most recently, Climate Vulnerable Forum (CVF). (2022). *Paris Goals NDC Alignment: Traffic Light Assessment*. CVF. Accessed 12 July 2023. https://thecvf.org/wp-content/uploads/2022/11/CVF_PTLAReport_2022.pdf; A.L. Fanning and J. Hickel. (2023). 'Compensation for Atmospheric Appropriation'. *Nature Sustainability*. Accessed 12 July 2023. https://doi.org/10.1038/s41893-023-01130-8; M. Grasso and R. Heede. (2023). 'Time to Pay the Piper: Fossil Fuel Companies' Reparations for Climate Damages'. *One Earth*, 6(5), 459–63. https://doi.org/10.1016/j.oneear.2023.04.012

[11] For a recent overview and critique of several such studies, see K. Dooley, C. Holz, S. Kartha, S. Klinsky, J. Timmons Roberts, H. Shue, H. Winkler, et al. (2021). 'Ethical Choices Behind Quantifications of Fair Contributions Under the Paris Agreement'. *Nature Climate Change*, 11, 300–305. https://doi.org/10.1038/s41558-018-0152-7

[12] Given that the NDCs are frequently updated, many published assessments are now out-of-date and could not be included here (e.g. X. Pan, M. den Elzen, N. Höhne, F. Teng and L. Wang. (2017). 'Exploring Fair and Ambitious Mitigation Contributions Under the Paris Agreement Goals'. *Environmental Science & Policy*, 74, 49–56. https://doi.org/10.1016/j.envsci.2017.04.020; Y. Robiou du Pont, M.L. Jeffery, J. Gütschow, J. Rogelj, P. Christoff and M. Meinshausen. (2017). 'Equitable Mitigation to Achieve the Paris Agreement Goals'. *Nature Climate Change*, 7, 38–43. https://doi.org/10.1038/nclimate3186). The NDC quantifications of the three approaches chosen have been kept up to date, at least with regards to the G20 countries that they cover. This discussion paper includes updates of NDCs up to 31 May 2023.

[13] T. Gore. (2021). *Carbon Inequality in 2030: Per Capita Consumption Emissions and the 1.5°C Goal*. Institute for European Environmental Policy and Oxfam. Accessed 12 July 2023. https://policy-practice.oxfam.org/resources/carbon-inequality-in-2030-per-capita-consumption-emissions-and-the-15c-goal-621305; E. Ghosh, S. Kartha and A. Nazareth. (2022). *The Inequality-Emissions Link and What It Means for the 1.5°C Goal. SEI Methodological Note (Pre-Print)*. Stockholm Environment Institute. Accessed 12 July 2023. https://www.sei.org/wp-content/uploads/2022/01/220109a-burton-ghosh-inequality-report-2111a.pdf

[14] Ibid.

[15] For a more general and thorough critique of using equal-per-capita approaches as equity benchmarks, see K. Dooley et al. (2021). 'Ethical Choices Behind Quantifications', op cit.

[16] Climate Action Tracker (CAT). (2021). *CAT Rating Methodology – Overview (September 2021 version)*. Climate Action Tracker. Accessed 12 July 2023. https://climateactiontracker.org/methodology/cat-rating-methodology/

[17] For this approach, the CAT utilizes emissions for the scenario pathways from integrated assessment models that are the basis of the IPCC's Special Report on 1.5°C. Since these pathways only provide emissions data for five large world regions, as opposed to individual countries, the CAT applies a simple downscaling heuristic, that does not involve any equity considerations, to disaggregate the emissions to individual countries. For details on the approach, see CAT. (2021). *Modelled Domestic Pathways*. Climate Action Tracker. Accessed 12 July 2023. https://climateactiontracker.org/methodology/cat-rating-methodology/modelled-domestic-pathways. For details on the underlying scenario data see D. Huppmann, E. Kriegler, V. Krey, K. Riahi, J. Rogelj, S.K. Rose, J. Weyant, et al. (2018). *IAMC 1.5°C Scenario Explorer and Data Hosted by IIASA*. Integrated Assessment Modeling Consortium & International Institute for Applied Systems Analysis. Accessed 12 July 2023. https://doi.org/10.22022/SR15/08-2018.15429; IPCC. (2018). *Special Report on the Impacts of Global Warming of 1.5°C*, op cit.

[18] CAT. (2021). *CAT Rating Methodology*, op cit.

[19] 'Grandfathering' is used here in quotation marks to denote (and denounce) the sexist and racist origins of the term as a cynical set of policies that, in the post-civil-war USA, were designed to continue denying African Americans the newly-won right to vote via ostensibly universal but in practice race-specific barriers to voting. In its metaphorical use in the context of mitigation effort sharing, it describes an approach that allocates mitigation effort in such a way that countries' *relative* emissions levels remain constant even as the global emissions level goes down. That is, a country emitting 20% of current emissions would also emit 20% of (albeit overall much lower) future emissions. The same effort sharing outcome also results from applying the same percentage reduction to all countries, say 45% below 2010 levels by 2030. The approach is widely recognized as inequitable (see S. Caney. (2009). 'Justice and the Distribution of Greenhouse Gas Emissions'. *Journal of Global Ethics*, 5(2), 125–46. https://doi.org/10.1080/17449620903110300; Dooley et al. (2021). 'Ethical Choices Behind Quantifications', op cit.), though its use is sometimes justified on instrumental grounds (e.g. for political effectiveness; see C. Knight. (2013). 'What is Grandfathering?' *Environmental Politics*, 22(3), 410–427. https://doi.org/10.1080/09644016.2012.740937).

[20] A recent study, in which several of CAT's authors were involved, demonstrated that the explicit exclusion of 'grandfathering'-based approaches only results in minor changes to the resulting assessment, thus suggesting that the CAT's results would likewise not be strongly influenced by such an exclusion. See L. Rajamani, L. Jeffery, N. Höhne, F. Hans, A. Glass, G. Ganti and A. Geiges. (2021). 'National "Fair Shares" in Reducing Greenhouse Gas Emissions Within the Principled Framework of International Environmental Law'. *Climate Policy*, 21(8), 983–1004. https://doi.org/10.1080/14693062.2021.1970504

[21] N. Höhne, M. den Elzen and D. Escalante. (2014). 'Regional GHG Reduction Targets Based on Effort Sharing: A Comparison of Studies'. *Climate Policy*, 14(1), 122–47. https://doi.org/10.1080/14693062.2014.849452

[22] G. Ganti, A. Geiges, L. Jeffery, H. Fekete, M.J. Gidden, M. Schaeffer, B. Hare, et al. (2021). *Preprint of: Fair National Greenhouse Gas Reduction Targets Under Multiple Equity Perspectives – A Synthesis Framework*. Accessed 12 July 2023. https://www.researchsquare.com/article/rs-397507/v1

[23] For transparency, it should be noted that the author of this discussion paper is also one of the authors of this approach and an employee of the Climate Equity Reference Project. The CERP effort sharing framework was previously known as Greenhouse Development Rights (GDRs).

[24] P. Baer, T. Athanasiou, S. Kartha and E. Kemp-Benedict. (2008). *The Greenhouse Development Rights Framework. The Right to Development in a Climate Constrained World*, Second Edition. Berlin: Heinrich Böll Foundation, Christian Aid, EcoEquity and the Stockholm Environment Institute. Accessed 12 July 2023. https://www.boell.de/sites/default/files/Ecologgy_GDR-second-edition-i.pdf; P. Baer, G. Fieldman, T. Athanasiou and S. Kartha. (2008). Greenhouse Development Rights, op cit.; P. Baer, S. Kartha, T. Athanasiou and E. Kemp-Benedict. (2009). 'The Greenhouse Development Rights Framework', op cit.

[25] United Nations Framework Convention on Climate Change (UNFCCC). (1992). *United Nations Framework Convention on Climate Change*. Bonn: UNFCCC. Accessed 12 July 2023. http://unfccc.int/resource/docs/convkp/conveng.pdf

[26] D. Huppmann, E. Kriegler, V. Krey, K. Riahi, J. Rogelj, S.K. Rose, J. Weyant, et al. (2018). *IAMC 1.5°C Scenario Explorer,* op cit.

[27] H. Shue. (1993). 'Subsistence Emissions and Luxury Emissions'. *Law & Policy*, 15(1), 39–60. https://doi.org/10.1111/j.1467-9930.1993.tb00093.x

[28] C. Holz, S. Kartha and T. Athanasiou. (2018b). *CERP Core Database v7.2.0 Documentation*. Climate Equity Reference Calculator Database, version 7.2.0 (Sep 2018). Harvard Dataverse. https://doi.org/10.7910/DVN/03H22Z/FBXUWU

[29] E. Kemp-Benedict, T. Athanasiou, P. Baer, C. Holz and S. Kartha. (2018). *Calculations for the Climate Equity Reference Calculator (CERc)*. Climate Equity Reference Project Working Paper Series, WP002. Stockholm Environment Institute. Accessed 12 July 2023. https://doi.org/10.5281/zenodo.1748847

[30] For a more complete explanation, see E. Kemp-Benedict, T. Athanasiou, P. Baer, C. Holz and S. Kartha. (2018). *Calculations for the Climate Equity Reference Calculator*, op cit.

[31] T. Gore. (2021). *Carbon Inequality in 2030*, op cit.; E. Ghosh et al. (2022). *The Inequality-Emissions Link and What It Means for the 1.5°C Goal*, op cit.; S. Kartha, E. Kemp-Benedict, E. Ghosh, et al. (2020). *The Carbon Inequality Era*, op cit.

[32] See E. Ghosh et al. (2022). *The Inequality-Emissions Link and What It Means for the 1.5°C Goal*, op cit. The NDC data in Ghosh et al. (2022) has an NDC cutoff date of 1 October 2021; however, data for the G20 countries that have updated their NDC since then has been provided to Oxfam by the Ghosh team privately (5 May 2023) and is expected to be published soon.

[33] For Brazil and Argentina, non-CO_2 GHGs accounted for around half of total GHGs (excluding LULUCF) in 2010, while non-CO_2 GHGs accounted for between a quarter and a third for Australia, India, Indonesia and Mexico. For all other G20 countries, the share of non-CO_2 GHGs was below 25%.

[34] E. Ghosh et al. (2022). The Inequality-Emissions Link and What It Means for the 1.5°C Goal, op cit.

[35] T. Gore. (2021). *Carbon Inequality in 2030*, op cit.

[36] The Civil Society Equity Review, which utilizes the CERP approach, did such a complete assessment of countries' 2020 pledges (mitigation and finance) in 2016 and found that taking into account the climate finance provided by wealthier countries does not alter the assessment results substantially, since the levels of finance are simply too low to make an impact. See Civil Society Equity Review. (2016). *Setting the Path Towards 1.5°C: A Civil Society Equity Review of Pre-2020 Ambition*. Manila: CSO Equity Review Coalition. Accessed 12 July 2023. https://equityreview.org/report2016

[37] In the new CAT hybrid ambition benchmarking analyses, for 'developing' countries this distinction is implemented by an additional element which assesses whether the country has made additional mitigation NDC commitments that are conditional on external finance and support and that are consistent with downscaled modelled mitigation pathways, with the latter being a proxy measure for the amount of physical mitigation that should take place in the country to be in line with a 1.5°C-consistent pathway. For 'developed' countries, it is implemented by having an additional element that considers the climate finance provided or pledged by 'developed' countries for additional mitigation outside their borders. In the CERP fair shares assessment, the main results chart of CERP's Climate Equity Reference Calculator shows, in addition to the fair share line, a line with indicative domestic emissions, which are for 'developed' countries typically much less stringent than the fair share of the country would imply, while the reverse is typically true for 'developing' countries.

[38] IPCC. (2014). *Fifth Assessment Report (AR5)*. Accessed 13 July 2023. https://www.ipcc.ch/assessment-report/ar5

[39] The CAT uses five different rating levels for its assessment, the highest being '1.5°C consistent,' followed by 'almost sufficient,' 'insufficient,' 'highly insufficient,' and 'critically insufficient'.

[40] In all cases in this report, when averaging across aggregations of countries, the averages reported are weighted averages, using 2030 projected population as each country's weight (using the UN Population Division's medium variant projections; see UN. (2019). *World Population Prospects: The 2019 Revision*, op cit.).

[41] C. Holz, E. Kemp-Benedict, T. Athanasiou and S. Kartha. (2019). 'The Climate Equity Reference Calculator'. *Journal of Open Source Software*, 4(35), 1273. https://doi.org/10.21105/joss.01273; E. Kemp-Benedict, C. Holz, T. Athanasiou, S. Kartha and P. Baer. (2022). *The Climate Equity Reference Calculator*. EcoEquity and Stockholm Environment Institute. Accessed 12 July 2023. https://calculator.climateequityreference.org

[42] CAT. (2023). Country Assessments (May 2023), op cit.

[43] M. Meinshausen, J. Lewis, J. Gütschow, Z. Nicholls and R. Burdon. (2022). *NDC Factsheets. Version 14 February 2022.* Climate Resource. Accessed 12 July 2023. https://www.climate-resource.com/tools/ndcs

[44] T. Gore. (2021). *Carbon Inequality in 2030*, op cit.

[45] Ibid.

[46] E. Ghosh et al. (2022). The Inequality-Emissions Link and What It Means for the 1.5°C Goal, op cit.

[47] T. Gore. (2021). *Carbon Inequality in 2030*, op cit.;

[48] E. Ghosh et al. (2022). The Inequality-Emissions Link and What It Means for the 1.5°C Goal, op cit.

[49] UNEP. (2022). *Emissions Gap Report 2022: The Closing Window – Climate Crisis Calls for Rapid Transformation of Societies*. Nairobi: United Nations Environment Programme (UNEP). Accessed 12 July 2023. https://www.unep.org/resources/emissions-gap-report-2022

APPENDIX: FURTHER ANALYSIS

SUMMARY

Table 2 below shows the top-level results across the three approaches discussed above, plus the CAT Hybrid Ambition Assessment results. Furthermore, table 3 shows a summary of the main assessment metrics and additional information for each G20 country as well as aggregated metrics for groups of countries (G20 as a whole, high-income G20, and low-income G20 countries). Table 2 is sorted by average rank of each country across the three approaches, i.e. countries at the top rank on average the worst and those at the bottom rank on average best.

Most notable across the board is the dominance of dark shades of blue, clearly showing that as a group, but also in most cases individually, G20 countries fall far short of what they should be expected to contribute to the global mitigation effort.

Table 2: Comparison of Assessment Approaches for all G20 countries. Note: Table is sorted by average rank across approaches

	Equal consumption CO_2 per capita	CERP fair share	CAT effort sharing	CAT hybrid
United States	exceeds by more than 4 times	exceeds by more than 10t/cap	Insufficient	Insufficient
Russia	exceeds by more than 4 times	exceeds by less than 10t/cap	Critically insufficient	Critically insufficient
Australia	exceeds by less than 4 times	exceeds by more than 10t/cap	Insufficient	Insufficient
Germany	exceeds by less than 4 times	exceeds by more than 10t/cap	Insufficient	Insufficient
South Korea	exceeds by less than 4 times	exceeds by less than 5t/cap	Highly insufficient	Highly insufficient
Saudi Arabia	exceeds by less than 4 times	exceeds by less than 10t/cap	Critically insufficient	Highly insufficient
Japan	exceeds by less than 4 times	exceeds by more than 10t/cap	Insufficient	Insufficient
Türkiye	exceeds by less than 4 times	exceeds by less than 5t/cap	Critically insufficient	Critically insufficient
Canada	exceeds by less than 4 times	exceeds by more than 10t/cap	Insufficient	Highly insufficient
United Kingdom	exceeds by less than double	exceeds by more than 10t/cap	Insufficient	Almost sufficient
European Union	exceeds by less than double	exceeds by less than 10t/cap	Insufficient	Insufficient
Italy	exceeds by less than double	exceeds by less than 10t/cap	Missing	Missing
France	exceeds by less than double	exceeds by more than 10t/cap	Missing	Missing
China	exceeds by less than 4 times	1.5°C fair share compliant	Highly insufficient	Highly insufficient
Indonesia	exceeds by less than double	exceeds by less than 5t/cap	Critically insufficient	Highly insufficient
Mexico	exceeds by less than double	exceeds by less than 5t/cap	Critically insufficient	Highly insufficient
Argentina	exceeds by less than double	exceeds by less than 1t/cap	Highly insufficient	Highly insufficient
Brazil	1.5°C consistent	exceeds by less than 5t/cap	Insufficient	Insufficient
India	1.5°C consistent	exceeds by less than 1t/cap	Insufficient	Highly insufficient
South Africa	exceeds by less than 1/4	1.5°C fair share compliant	Insufficient	Insufficient

Table 3: Summary of the ambition and/or fair shares assessment results according to CAT, CERP and EPCCC approaches, for each G20 country

Country *Income group*	**Argentina** Middle-income country			**Australia** High-income country			**Brazil** Middle-income country			**Canada** High-income country		
Approach *Unit*	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap
Current emissions	7.1	7.7	3.7	18.3	20.3	14.0	4.9	5.4	2.3	16.5	18.1	13.7
NDC emissions 2030	6.4	6.4	3.2	13.3	10.6	7.8	4.3	5.3	1.8	10.3	10.0	7.2
1.5°C benchmark 2030	3.9	5.9	2.3	9.2	-7.4	2.3	3.8	2.9	2.3	7.3	-5.6	2.3
Shortfall	2.5	0.6	0.9	4.1	18.0	5.5	0.5	2.5	-0.5	3.0	15.6	4.9
Rating according to approach	Highly insufficient	exceeds by less than 1t/cap	exceeds by less than double	Insufficient	exceeds by more than 10t/cap	exceeds by less than 4 times	Insufficient	exceeds by less than 5t/cap	1.5°C consistent	Insufficient	exceeds by more than 10t/cap	exceeds by less than 4 times

Country *Income Group*	**China** Middle-income country			**European Union** High-income country			**France** High-income country			**Germany** High-income country		
Approach *Unit*	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap
Current Emissions	9.8	10.0	7.1	7.8	7.8	7.7		6.3	6.0	9.2	9.1	9.9
NDC emissions 2030	9.2	9.9	7.3	5.0	4.9	4.6	missing	4.7	3.4	5.2	5.2	6.4
1.5°C benchmark 2030	5.7	9.9	2.3	0.8	-4.0	2.3	from	-7.3	2.3	-1.3	-8.8	2.3
Shortfall	3.4	0.0	5.0	4.2	9.0	2.3	CAT	12.0	1.1	6.5	14.0	4.1
Rating according to Approach	Highly insufficient	1.5°C Fair Share compliant	exceeds by less than 4 times	Insufficient	exceeds by less than 10t/cap	exceeds by less than double		exceeds by more than 10t/cap	exceeds by less than double	Insufficient	exceeds by more than 10t/cap	exceeds by less than 4 times

Country *Income Group*	**India** Middle-income country			**Indonesia** Middle-income country			**Italy** High-income country			**Japan** High-income country		
Approach *Unit*	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap
Current Emissions	2.2	2.5	1.8	3.2	3.4	2.5		6.8	7.0	9.7	9.4	9.8
NDC emissions 2030	3.0	2.9	2.0	6.0	5.8	4.0	missing	5.5	4.4	6.7	6.7	6.9
1.5°C benchmark 2030	2.3	2.9	2.3	2.9	3.6	2.3	from	-4.5	2.3	3.1	-8.8	2.3
Shortfall	0.7	0.1	-0.3	3.2	2.3	1.7	CAT	10.0	2.1	3.7	15.5	4.6
Rating according to Approach	Insufficient	exceeds by less than 1t/cap	1.5°C consistent	Critically insufficient	exceeds by less than 5t/cap	exceeds by less than double		exceeds by less than 10t/cap	exceeds by less than double	Insufficient	exceeds by more than 10t/cap	exceeds by less than 4 times

Country *Income Group*	**Mexico** Middle-income country			**Russia** Middle-income country			**Saudi Arabia** High-income country			**South Africa** Middle-income country		
Approach *Unit*	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap
Current Emissions	5.0	5.3	4.0	15.1	15.1	9.5	14.9	18.3	17.8	7.6	8.9	5.5
NDC emissions 2030	5.6	4.3	4.4	16.8	15.6	9.5	13.3	18.1	9.2	5.5	5.5	2.8
1.5°C benchmark 2030	3.0	3.1	2.3	6.8	8.0	2.3	9.6	12.3	2.3	5.3	5.9	2.3
Shortfall	2.6	1.3	2.1	10.0	7.6	7.2	3.7	5.8	6.9	0.3	-0.4	0.5
Rating according to Approach	Critically insufficient	exceeds by less than 5t/cap	exceeds by less than double	Critically insufficient	exceeds by less than 10t/cap	exceeds by more than 4 times	Critically insufficient	exceeds by less than 10t/cap	exceeds by less than 4 times	Insufficient	1.5°C Fair Share compliant	exceeds by less than 1/4

Country *Income Group*	**South Korea** High-income country			**Türkiye** Middle-income country			**United Kingdom** High-income country			**United States** High-income country		
Approach *Unit*	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap	***CAT*** tCO_2eq/cap	***CERP*** tCO_2eq/cap	***EPCCC*** tCO_2/cap
Current Emissions	13.4	13.4	13.6	6.3	6.7	4.8	5.9	6.3	7.5	17.9	18.5	17.0
NDC emissions 2030	9.1	8.5	8.9	8.6	8.7	7.4	3.5	3.1	3.9	11.1	10.3	9.4
1.5°C benchmark 2030	4.6	5.2	2.3	4.3	3.9	2.3	-2.1	-7.9	2.3	5.3	-14.4	2.3
Shortfall	4.6	3.4	6.6	4.3	4.8	5.1	5.7	11.1	1.6	5.8	24.6	7.1
Rating according to Approach	Highly insufficient	exceeds by less than 5t/cap	exceeds by less than 4 times	Critically insufficient	exceeds by less than 5t/cap	exceeds by less than 4 times	Insufficient	exceeds by more than 10t/cap	exceeds by less than double	Insufficient	exceeds by more than 10t/cap	exceeds by more than 4 times

For each G20 member, table shows World Bank income group classification, and for each of benchmarking approach: current per capita emissions, per capita emissions in 2030 under NDC implementation, per capita emissions under each assessment approach's 1.5°C benchmark, per capita shortfall between NDC and benchmark, and rating according to each approach. 'Current emissions' shows data for last year with available data: 2021 for CERP and most countries for CAT, 2020 for all other cases; table shows territorial emissions for all GHGs (excluding LULUCF) for CAT and CERP; consumption-based CO_2 emissions from industry and energy for EPCCC.

COUNTRY-BY-COUNTRY ANALYSIS

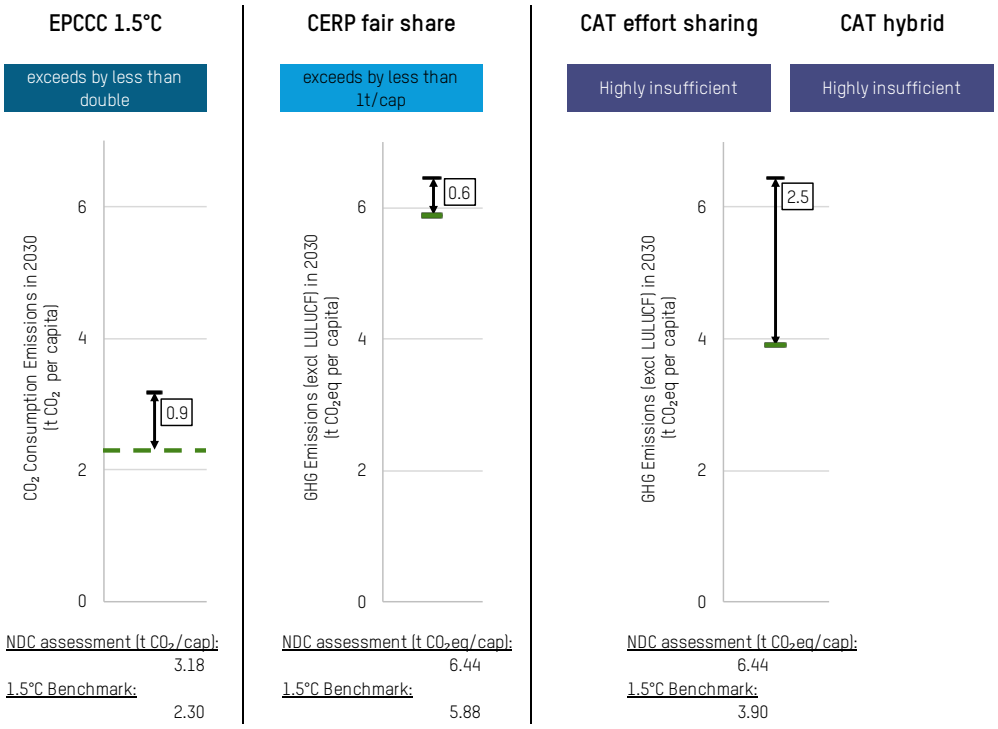
Argentina

Argentina's latest NDC was submitted on November 2, 2021.

CAT's assessment calculates the NDC target to result in emissions of 6.44 tCO_2eq/capita, which is a shortfall of 2.5 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Argentina thus earns a rating of "highly insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "highly insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 6.44 tCO_2eq per capita, which is 0.6 tCO_2eq above the 1.5°C fair share benchmark – one of the smallest per capita shortfalls among G20 countries.

Figure 9: Argentina results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Australia

Australia's latest NDC was submitted on June 16, 2022.

In the EPCCC analysis, Australia's NDC results in consumption CO_2 emissions of 7.8 tCO_2 per capita in 2030, more than three times the 2.3 tCO_2/cap equal-per-capita benchmark.

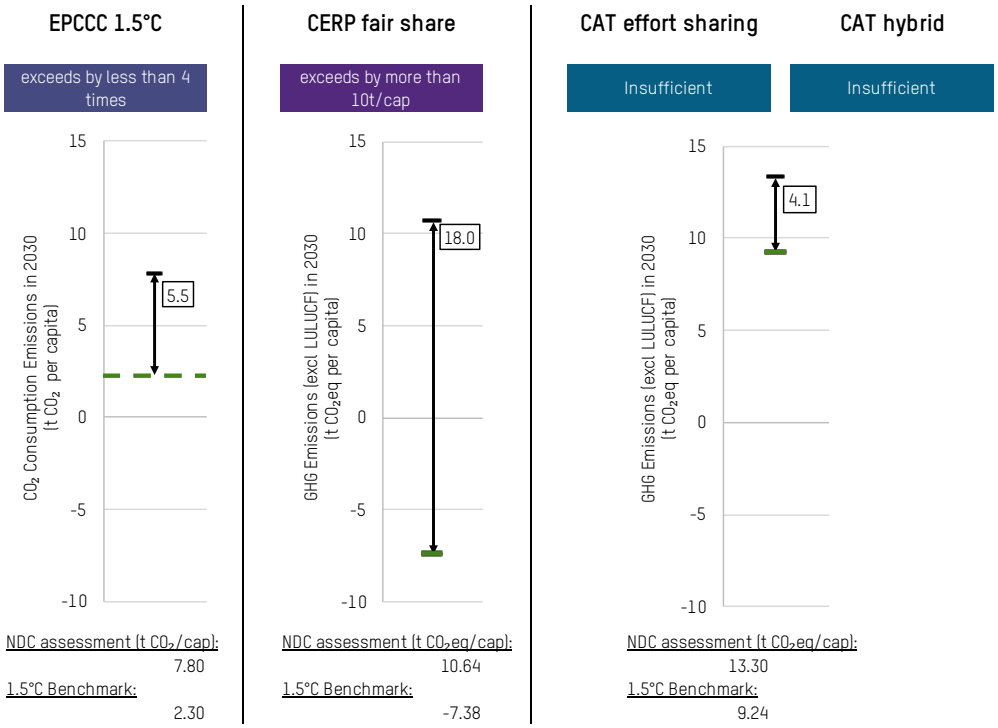
CAT's assessment calculates the NDC target to result in emissions of 13.3 tCO_2eq/capita, which is a shortfall of 4.1 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Australia thus earns a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is estimated to result in 2030 emissions of 10.6 tCO_2eq per capita, which is more than 18 tCO_2eq above the 1.5°C fair share benchmark. In other words, implementing

Australia's NDC would see Australia contribute less than half of its fair share to the global mitigation effort.

Across all of the approaches, Australia is among the bottom of the list of G20 countries, being one of the lowest performing 10 countries among the G20 countries. When comparing benchmarks, it is striking that the CAT effort sharing benchmark would allow Australia to maintain fairly high per capita emissions (more than three times the global average[1]) and still meet the benchmark requirement and would thus be the easiest for Australia to satisfy. The shortfall against the CAT benchmark is only about a quarter of the shortfall from the CERP 1.5°C fair share benchmark and about twice compared to the EPCCC benchmark. However, in balance the approaches still clearly indicate the need for Australia to substantially increase its NDC's mitigation pledge. Additionally, the large size of the shortfall in the EPCCC and CERP analyses also implies that a substantial increase in Australia's provision of climate finance is needed. This is also supported by the fact that Australia's CAT rating does not improve in the hybrid ambition assessment compared to the effort sharing assessment, indicating that Australia also performs poorly across the other ambition metrics, one of which is, for 'developed' countries, the provision of climate finance.

Figure 10: Australia results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Brazil

Brazil's latest NDC was submitted on April 7, 2022.

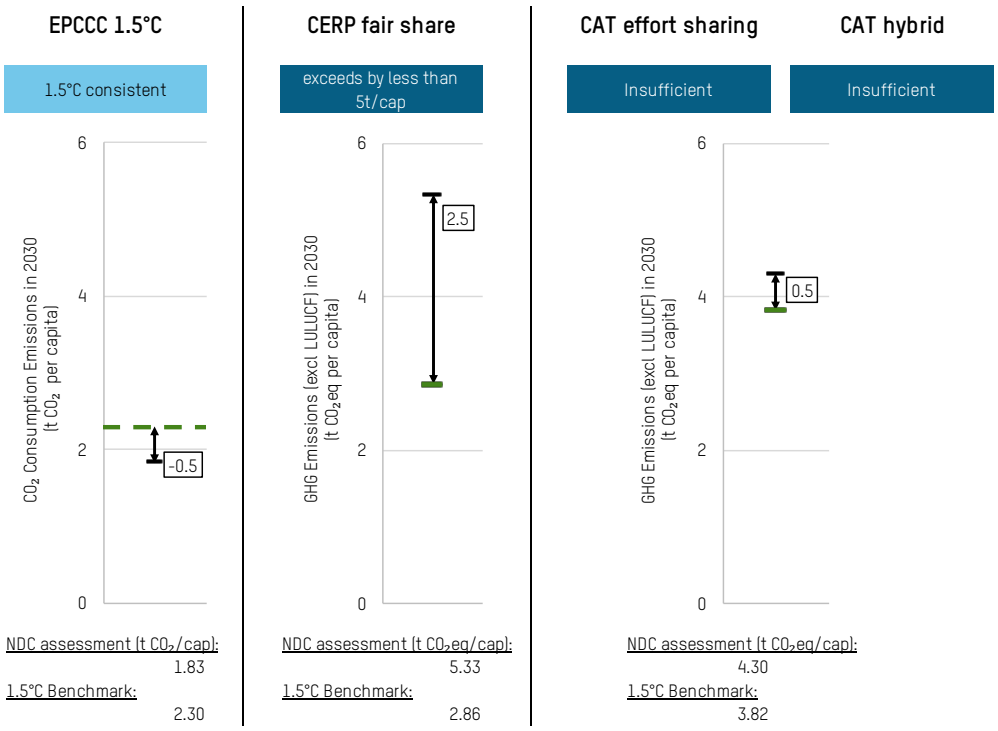
In the EPCCC analysis, Brazil's NDC results in consumption CO_2 emissions of 1.8 tCO_2 per capita in 2030, which is actually about 0.5 tCO_2/cap *below* the equal-per-capita benchmark. However, due to the NDC quantification approach of the EPCCC analysis, one should consider these results to be subject to a large degree of uncertainty due to the large role that LULUCF plays in Brazil's emissions.

[1] The 1.5°C pathway used by CAT has an emissions level of 25,951 $MtCO_2eq$ in 2030 (CAT 2021c). Divided by an estimated 8.5 billion people in the same year, yields a 1.5°C consistent average per capita level of 3.0 tCO_2eq for the CAT analysis. This number is different to the benchmark of the EPCCC approach since it includes non-CO_2 greenhouse gases.

CAT's assessment calculates the NDC target to result in emissions of 4.3 tCO_2eq/capita, which is a shortfall of 0.5 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Brazil thus earns a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 5.3 tCO_2eq per capita, which is 2.5 tCO_2eq above the 1.5°C fair share benchmark.

Figure 11: Brazil results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Across all assessments, Brazil is one of the G20 countries that comes closest to the relevant benchmarks, resulting in it being on the third best rank on average across the approaches.

It is very important to note, though, that any interpretation of these results must be done with caution. This is because the quantification of the NDC's impact in sectors other than LULUCF (which is required for both the CAT and CERP assessments) is subject to substantial uncertainty. Brazil's NDC features an economy-wide emissions reductions target without providing any further details on how this target is split between LULUCF and non-LULUCF sectors. Brazil selected the year 2005 as the base year for its target, when LULUCF emissions represented nearly two-thirds of total Brazilian emissions. Hence, the analysis of the mitigation impact of Brazil's NDC in sectors other than LULUCF depends greatly on its action (or inaction) in the LULUCF sector. As an illustration of this effect, compare the NDC quantification in the CERP analysis with CAT's, who make similar assumptions, but use a different LULUCF input data set. Perhaps somewhat controversially, the CERP quantification of Brazil's NDC assumes that no mitigation effort beyond the reference scenario[2] will be undertaken in

[2] Reference scenario emissions for LULUCF in 2030 are 298 $MtCO_2eq$ and are taken from a Brazilian Government projection study (R. Rathmann, R. Vieira Araujo, M. Rojas Da Cruz and A. Marcos Mendonça (2017). *Trajetórias De Mitigação E Instrumentos De Políticas Públicas Para Alcance Das Metas Brasileiras No Acordo De Paris*. Brasília: Ministério da Ciência, Tecnologia, Inovações e Comunicações. Accessed 12 July 2023. https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/acordo-de-paris-e-ndc/arquivos/pdf/trajetoriasebookb_final.pdf). In addition to these emissions from the LULUCF sector, the study also lists an expected credit of 268 $MtCO_2eq$ from sequestration by forests on indigenous lands and conservation lands, resulting in a net 30 $MtCO_2eq$ that is used here as the reference case net emissions from the LULUCF sector in 2030. 2005 emissions (LULUCF and non-LULUCF sectors) have been taken from Brazil's Fourth National Communication (Federal Republic of Brazil. (2020). *Fourth National Communication of Brazil to the UNFCCC*. Brasília: Ministry of Science, Technology and Innovations. Accessed 12 July 2023. https://unfccc.int/documents/267657).

LULUCF/deforestation. This approach has been taken to ensure that the quantification of the NDC's mitigation impact in non-LULCUF sectors is the most charitable result that is possible without assuming that Brazil would *increase* deforestation beyond the level in its reference scenario. Were Brazil, on the other hand, to actually reduce deforestation below that reference level – which it should do, since deforestation is a very important source of emissions –, the NDC assessment of the non-LULUCF sectors would become much less favourable.

Canada

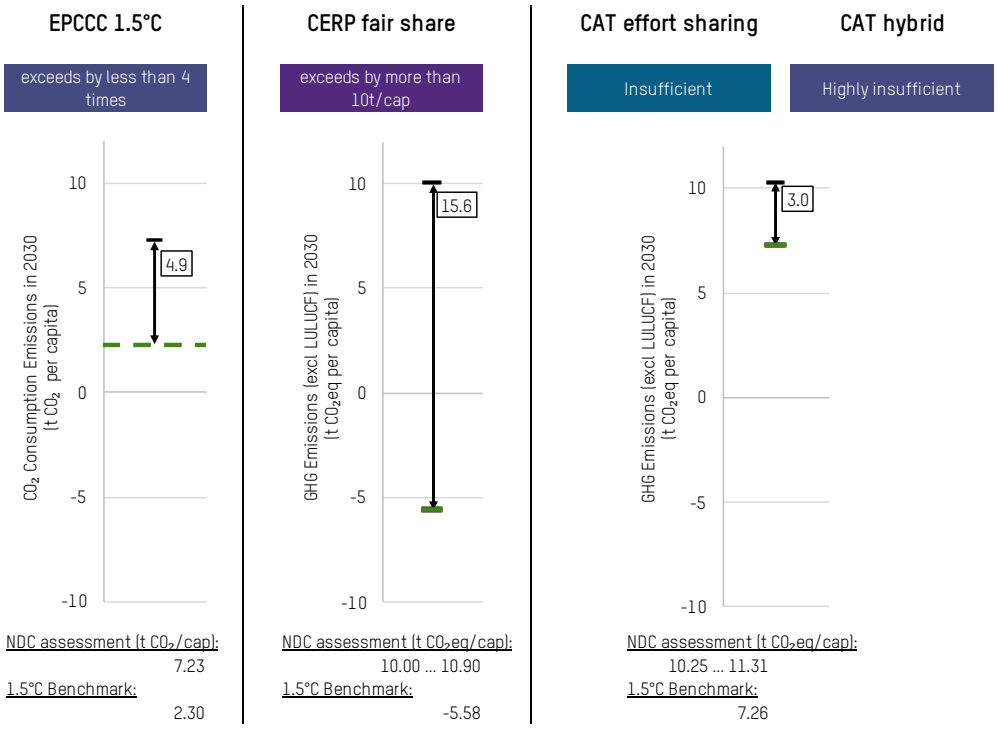
Canada's latest NDC was submitted on July 12, 2021.

In the EPCCC analysis, Canada's NDC results in consumption CO_2 emissions of 7.2 tCO_2 per capita in 2030, more than three times the 2.3 tCO_2/cap equal-per-capita benchmark.

CAT's assessment calculates the NDC target range to result in emissions of between 10.3 and 11.3 tCO_2eq/capita, which is a shortfall of 3.0 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Canada thus earns a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating drops to "highly insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is estimated to result in 2030 emissions in the range of 10.0 to 10.9 tCO_2eq per capita, which is more than 15.6 tCO_2eq above the 1.5°C fair share benchmark. In other words, implementing Canada's NDC would see Canada contribute less than half of its fair share to the global mitigation effort.

Figure 12: Canada results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Across all of the approaches, Canada is among the bottom of the list of G20 countries, being one of the lowest performing 10 countries among the G20 countries. When comparing benchmarks, it is clear that the CAT effort sharing benchmark would be the easiest for Canada to satisfy – the shortfall against that benchmark is only about half of that against the equal per capita benchmark and a quarter of the shortfall from the CERP 1.5°C fair share benchmark. This clearly indicates the need for Canada to substantially increase its NDC's mitigation pledge. However, the large size of the

shortfall in the equal-per-capita and CERP analyses also suggests that a substantial increase in Canada's provision of climate finance is needed. This latter point is also supported by the fact that Canada's CAT rating is lower in the hybrid ambition assessment compared to the effort sharing assessment, indicating that Canada also performs poorly across the other ambition metrics, one of which is, for 'developed' countries, the provision of climate finance.

China

China's latest NDC was submitted on October 28, 2021.

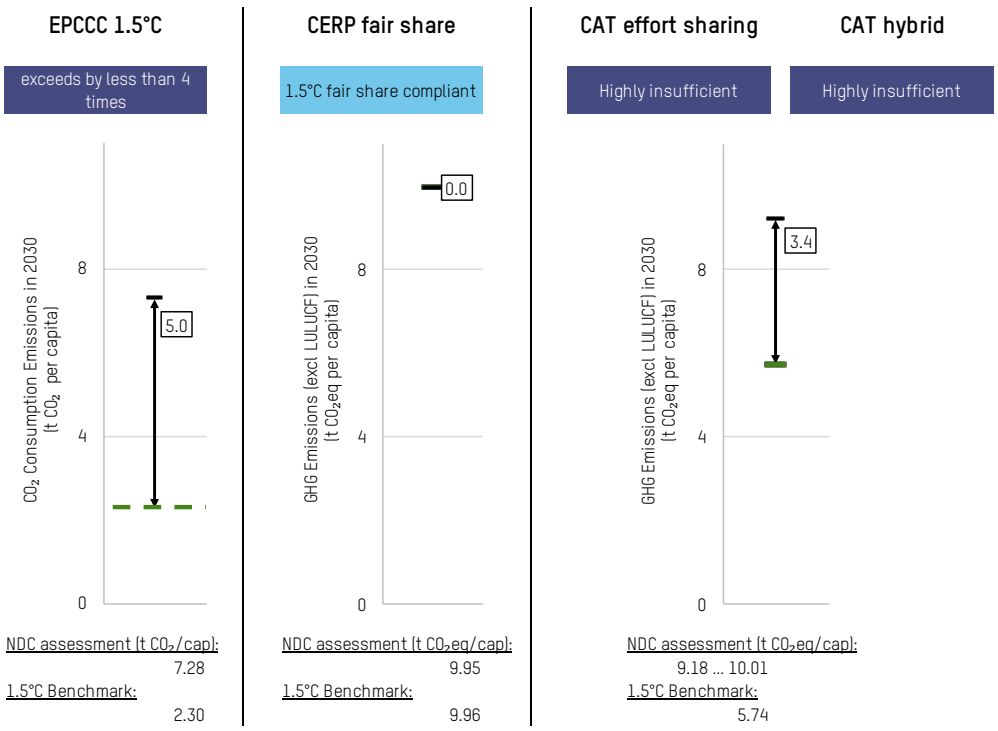
In the EPCCC analysis, China's NDC results in consumption CO_2 emissions of 7.3 tCO_2 per capita in 2030, about three times the 1.5°C-consistent level of 2.3 tCO_2/cap above the equal-per-capita benchmark.

CAT's assessment calculates the NDC target to result in emissions of between 9.2 and 10.0 tCO_2eq/capita, which is a shortfall of at least 3.4 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. China thus earns a rating of "highly insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "highly insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 9.95 tCO_2eq per capita, which nearly exactly matches the 1.5°C fair share benchmark, making it only one of two G20 countries (along with South Africa) to be considered 1.5°C fair share compliant by this assessment approach, and only one of three countries (along with South Africa and India) to meet the 1.5°C benchmark of any of the approaches discussed here.

As a result, across all assessments, China belongs to the G20 countries that come closer to the relevant benchmarks than others, being overall on the seventh best rank on average across the approaches.

Figure 13: China results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



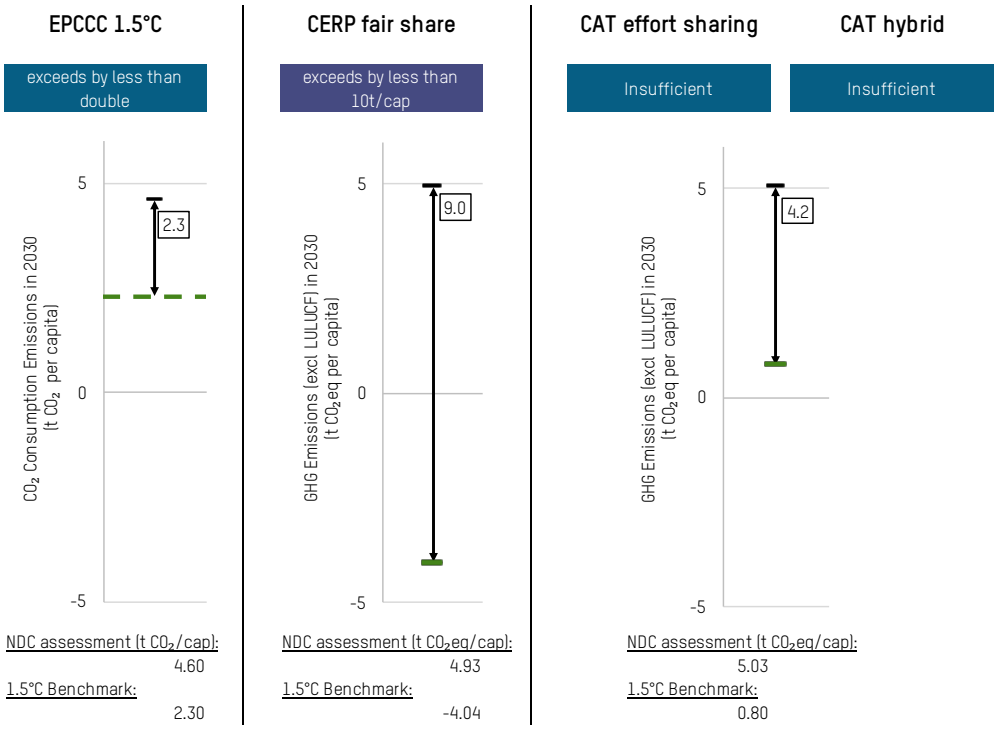
European Union

The EU's latest NDC was submitted on December 18, 2020. The EU submits a single NDC with a single EU-wide target for all of its member states. Additional EU-internal processes determine the respective targets of member states, as well as for the common emissions trading scheme, under this shared target. In this present section, the NDC and the fair shares and ambition of the entire EU and its member states is considered.

In the EPCCC analysis, The EU's NDC results in consumption CO_2 emissions of 4.6 tCO_2 per capita in 2030, twice the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions of 5.0 tCO_2eq/capita, which is a shortfall of at least 4.2 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. The EU thus earns a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "insufficient" in CAT's hybrid ambition benchmark.

Figure 14: European Union results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



In the CERP analysis, the NDC is considered to result in 2030 emissions of 4.9 tCO_2eq per capita, which is 9.0 tCO_2eq/cap above the 1.5°C fair share benchmark.

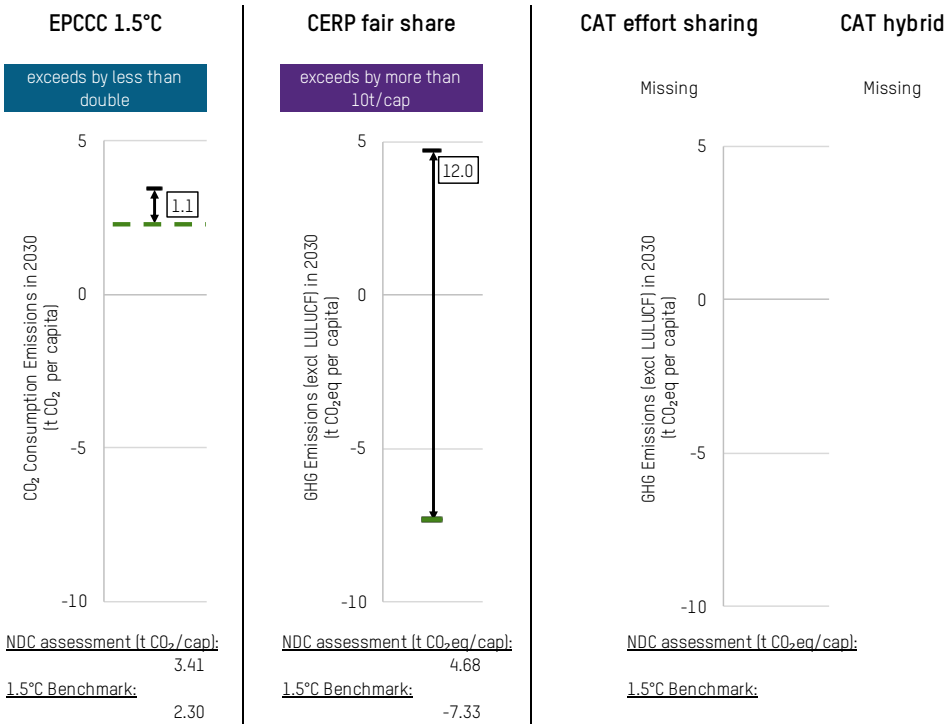
France

France's latest NDC is the EU's NDC which was submitted on December 18, 2020. The Climate Action Tracker does not assess France. As mentioned above, the EU submits a single NDC with a single EU-wide target for all of its member states. Additional EU-internal processes determine the respective targets of member states, as well as for the common emissions trading scheme, under this shared target. Thus, the emissions reductions required in each EU member state under the EU NDC are not the same as in the EU as a whole. In this present section, France's emissions reductions that result from the EU's NDC are considered.

In the EPCCC analysis, the EU's NDC would result in consumption CO_2 emissions in France of 3.4 tCO_2 per capita in 2030, less than twice the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

In the CERP analysis (using an NDC quantification from Meinshausen et al. 2022), the EU's NDC's implementation in France is considered to result in 2030 emissions of 4.7 tCO_2eq per capita, which is 12.0 tCO_2eq/cap above the 1.5°C fair share benchmark.

Figure 15: France results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Germany

Germany's latest NDC is the EU's latest NDC which was submitted on December 18, 2020. As mentioned above, the EU submits a single NDC with a single EU-wide target for all of its member states. Additional EU-internal processes determine the respective targets of member states, as well as for the common emissions trading scheme, under this shared target. Thus, the emissions reductions required in each EU member state under the EU NDC are not the same as in the EU as a whole. In this present section, Germany's emissions reductions that result from the EU's NDC are considered.

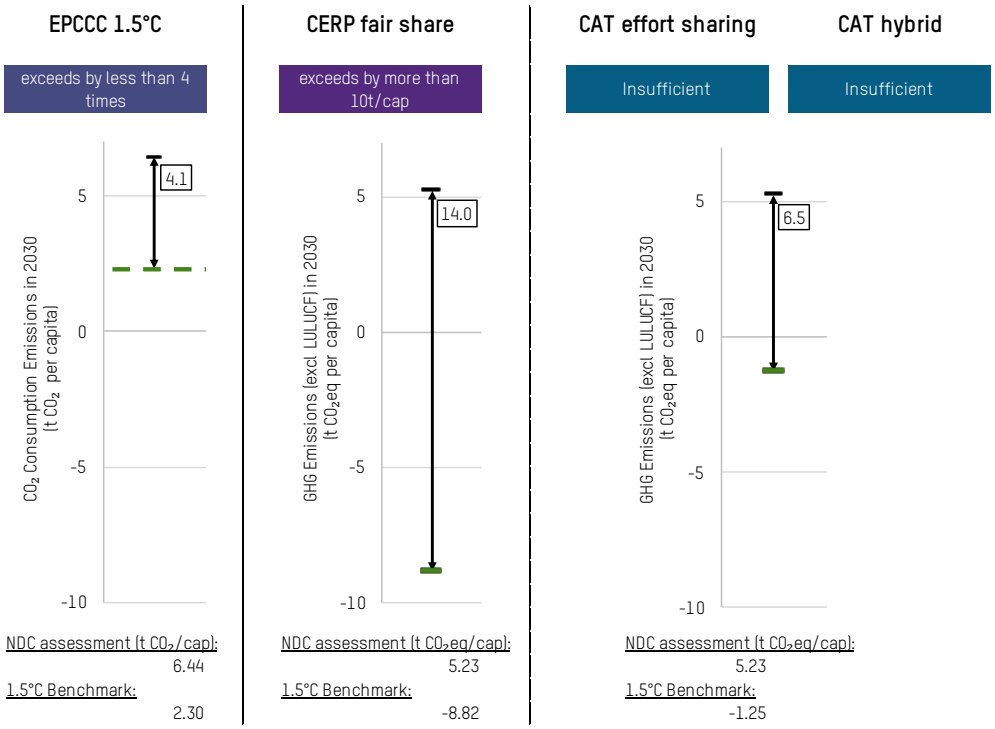
In the EPCCC analysis, Germany's implementation of its part of the EU's NDC results in consumption CO_2 emissions of 6.4 tCO_2 per capita in 2030, more than twice the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the implementation of the EU NDC target in Germany to result in emissions of 5.2 tCO_2eq/capita, which is a shortfall of at least 6.5 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Germany thus earns a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 5.2 tCO_2eq per capita (CAT's NDC quantification is used), which is 14 tCO_2eq/cap above the 1.5°C fair share benchmark, one of the largest shortfalls among G20 countries.

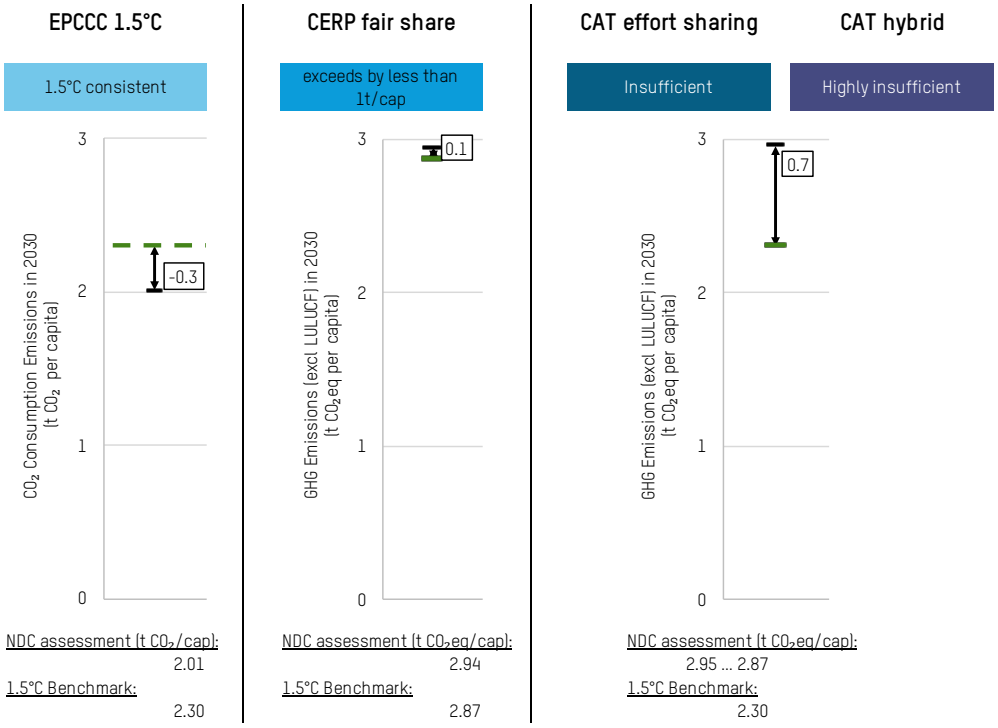
Across approaches, Germany has one of the poorest average rankings among G20 countries and is overall on the fifth worst rank when averaged across all three approaches.

Figure 16: Germany results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



India

Figure 17: India results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



India's latest NDC was submitted on August 26, 2022.

In the EPCCC analysis, India's NDC results in consumption CO_2 emissions of 2.0 tCO_2 per capita in 2030, just below the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap. This makes India the only country to meet EPCCC 1.5°C benchmark.

CAT's assessment calculates the NDC target to result in emissions of between 2.9 and 3.0 tCO_2eq/capita, which is a shortfall of about 0.7 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. India thus earns a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating is reduced to "highly insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 2.9 tCO_2eq per capita, which is less than 0.1 tCO_2eq/cap above the 1.5°C fair share benchmark.

Indonesia

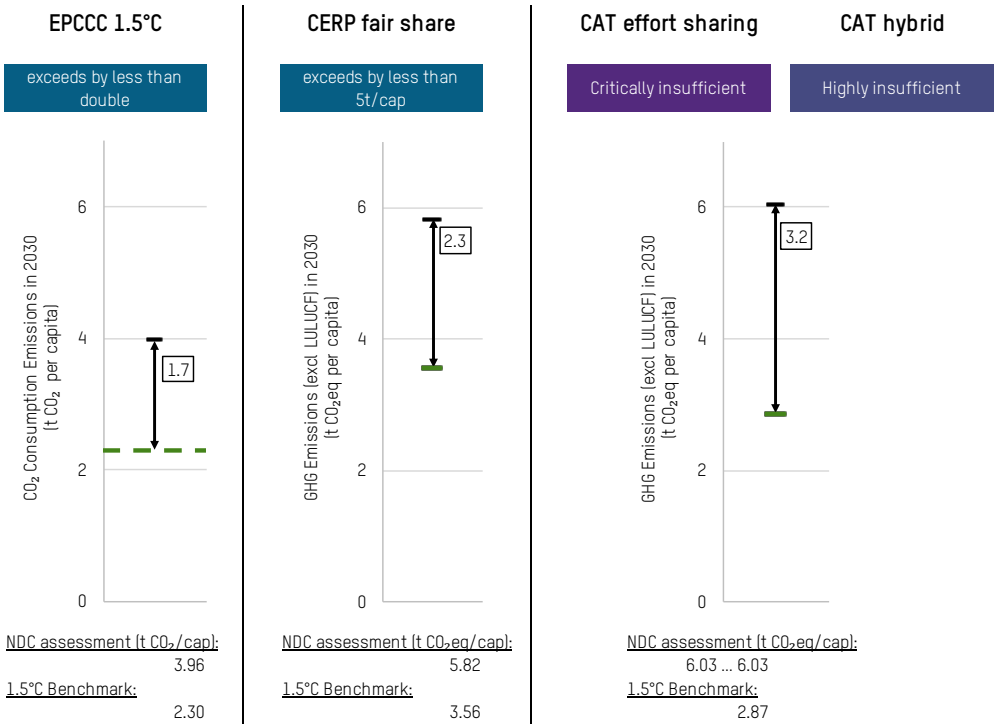
Indonesia's latest NDC was submitted on September 23, 2022.

CAT's assessment calculates the NDC target to result in emissions of 6.0 tCO_2eq/capita, which is a shortfall of about 3.2 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Indonesia thus earns a rating of "critically insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating improves to "highly insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 5.8 tCO_2eq per capita, which is 2.3 tCO_2eq/cap above the 1.5°C fair share benchmark.

Given the large role of LULUCF in Indonesia's emissions profile and the large degree of uncertainty that this imposes on NDC quantifications, these results should be interpreted with a great degree of caution.

Figure 18: Indonesia results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



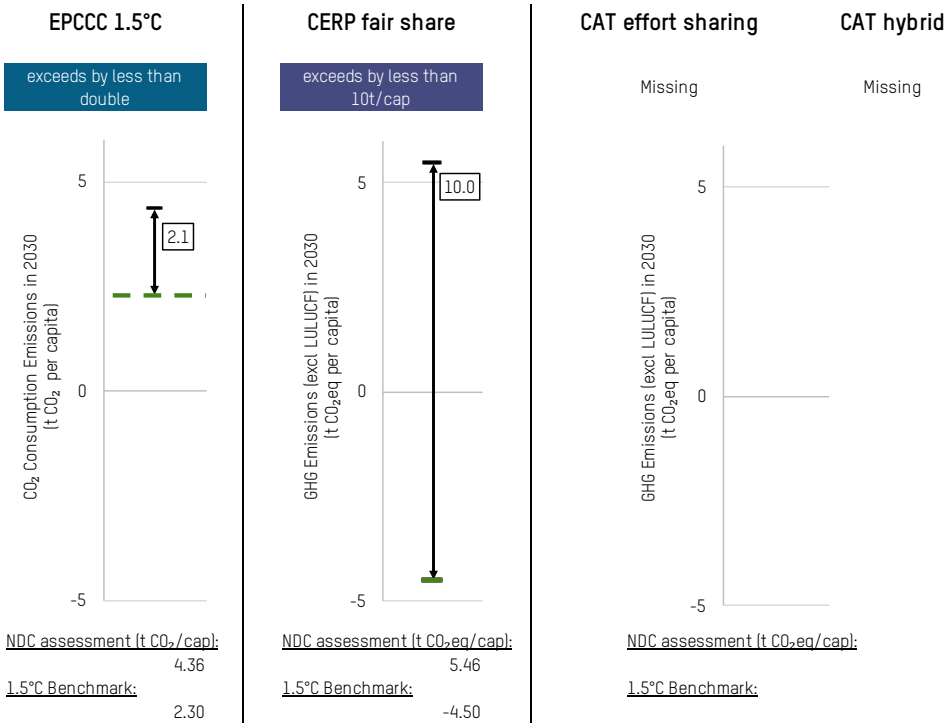
Italy

Italy's latest NDC is the EU's NDC which was submitted on December 18, 2020. The Climate Action Tracker does not assess Italy. As mentioned above, the EU submits a single NDC with a single EU-wide target for all of its member states. Additional EU-internal processes determine the respective targets of member states, as well as for the common emissions trading scheme, under this shared target. Thus, the emissions reductions required in each EU member state under the EU NDC are not the same as in the EU as a whole. In this present section, Italy's emissions reductions that result from the EU's NDC are considered.

In the EPCCC analysis, Italy's implementation of the EU's NDC results in consumption CO_2 emissions of 4.4 tCO_2 per capita in 2030, just under twice the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

In the CERP analysis (using an NDC quantification from Meinshausen et al. 2022), the EU NDC is considered to result in Italy in 2030 emissions of 5.5 tCO_2eq per capita, which is 10.0 tCO_2eq/cap above the 1.5°C fair share benchmark.

Figure 19: Italy results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Japan

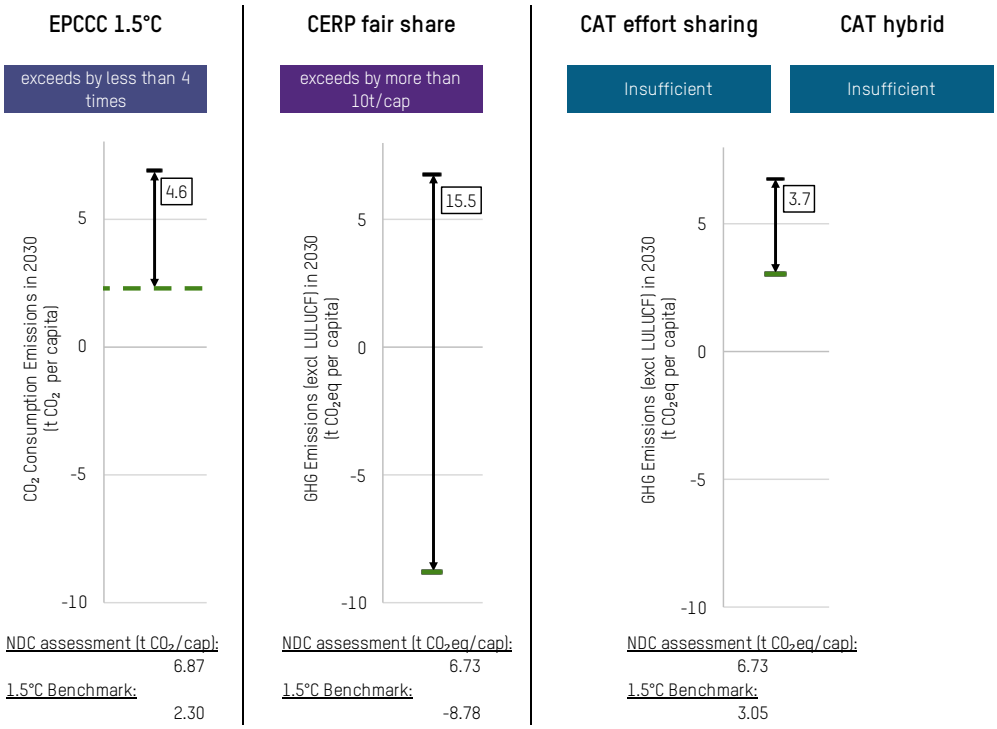
Japan's latest NDC was submitted on October 22, 2021.

In the EPCCC analysis, Japan's NDC results in consumption CO_2 emissions of 6.9 tCO_2 per capita in 2030, three times the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions of 6.7 tCO_2eq/capita, which is a shortfall of about 3.7 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Japan thus earns a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 6.7 tCO_2eq per capita, which is more than 15 tCO_2eq/cap above the 1.5°C fair share benchmark.

Figure 20: Japan results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Mexico

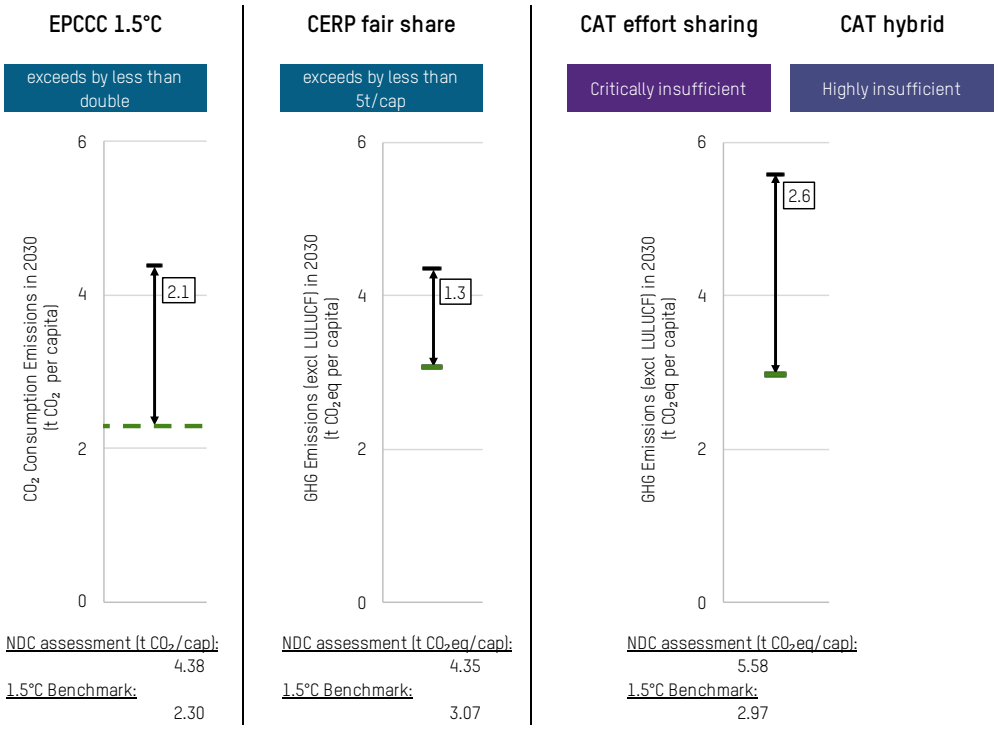
Mexico's latest NDC was submitted on November 17, 2022.

In the EPCCC analysis, Mexico's NDC results in consumption CO_2 emissions of 4.4 tCO_2 per capita in 2030, just under double the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions of 5.6 tCO_2eq/capita, which is a shortfall of about 2.6 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Mexico thus earns a rating of "critically insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating improves to "highly insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 4.4 tCO_2eq per capita, which is about 1.3 tCO_2eq/cap above the 1.5°C fair share benchmark.

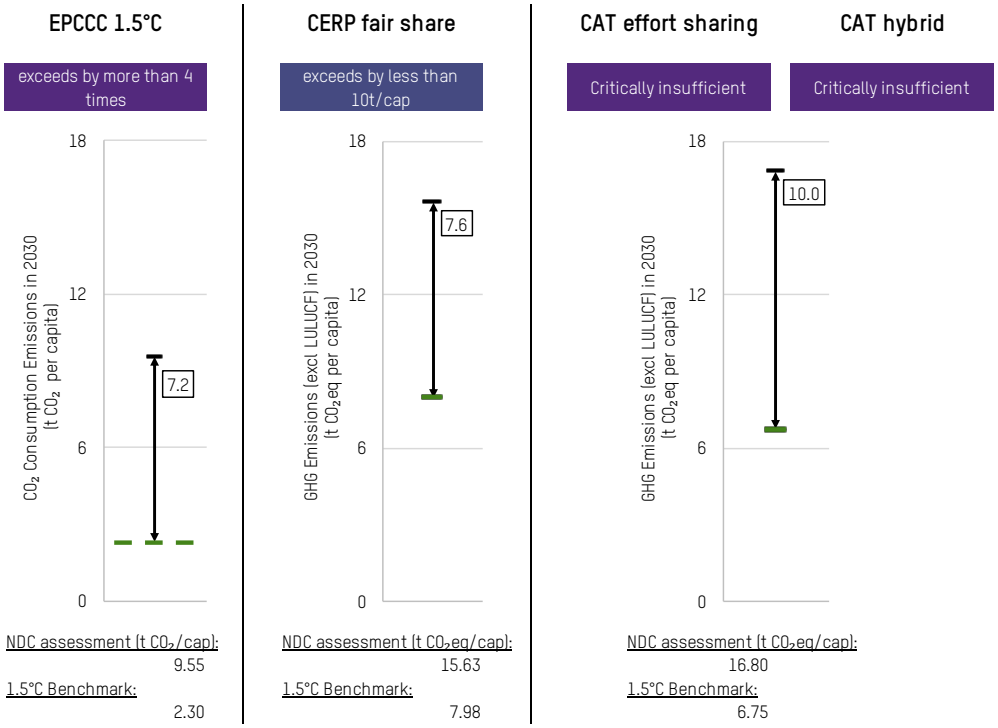
Figure 21: Mexico results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Russia

Russia's latest NDC was submitted on November 25, 2020.

Figure 22: Russia results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



In the EPCCC analysis, Russia's NDC results in consumption CO_2 emissions of 9.6 tCO_2 per capita in 2030, more than four times as much as the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions of 16.8 tCO_2eq/capita, which is a shortfall of about 10 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Russia thus earns a rating of "critically insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "critically insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 15.6 tCO_2eq per capita, which is about 8 tCO_2eq/cap above the 1.5°C fair share benchmark.

Across all three approaches, Russa is one of the poorest performers among G20 countries and its average ranking place it in the third lowest spot.

Saudi Arabia

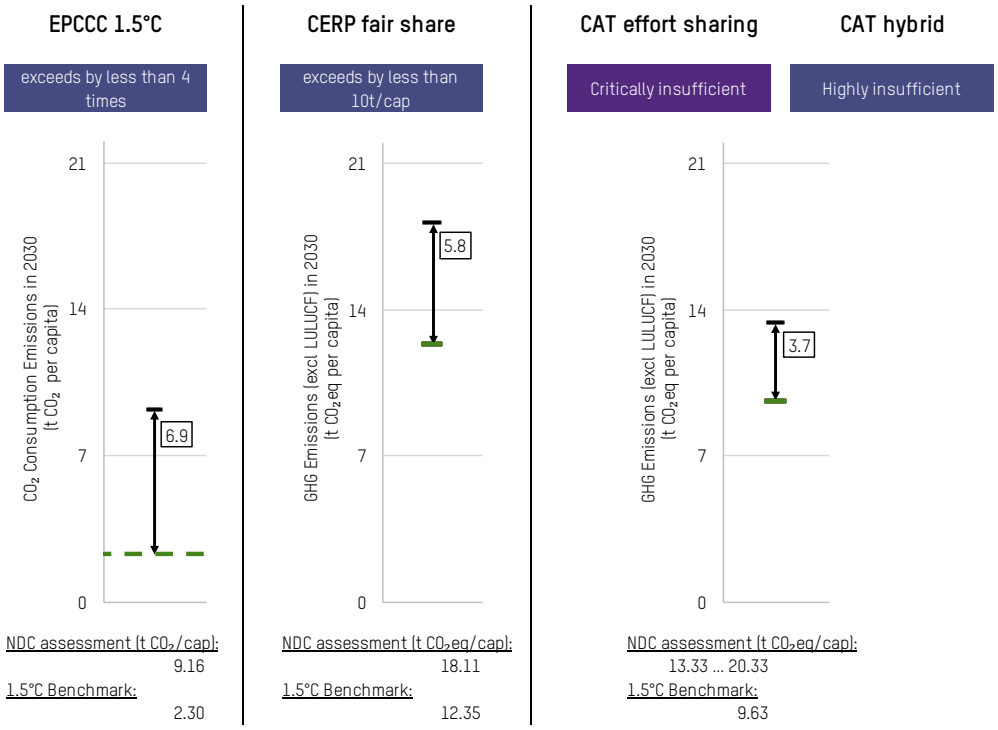
Saudi Arabia's latest NDC was submitted on October 23, 2021.

In the EPCCC analysis, Saudi Arabia's NDC results in consumption CO_2 emissions of 9.2 tCO_2 per capita in 2030, more than seven times the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions of in the range from 13.3 to 20.3 tCO_2eq/capita, which is a shortfall of at least 3.7 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. Saudi Arabia thus earns a rating of "critically insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating improves to "highly insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 18.1 tCO_2eq per capita, which is 5.8 tCO_2eq/cap above the 1.5°C fair share benchmark.

Figure 23: Saudi Arabia results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



South Africa

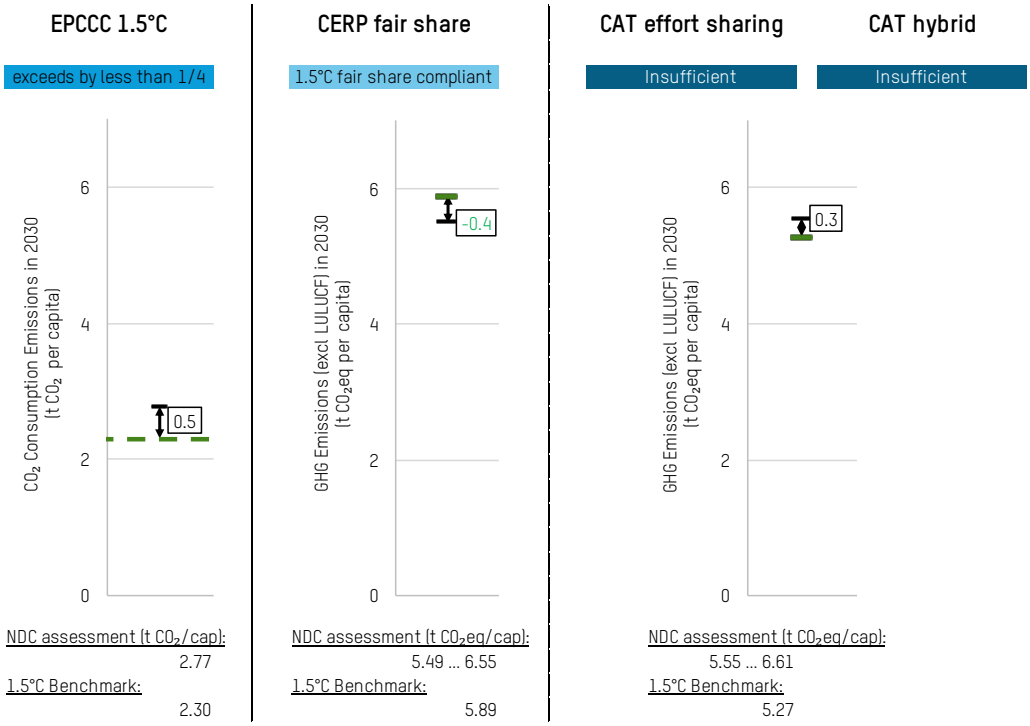
South Africa's latest NDC was submitted on September 27, 2021.

In the EPCCC analysis, South Africa's NDC results in consumption CO_2 emissions of 2.8 tCO_2 per capita in 2030, about 0.5 tCO_2eq/capita above the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions between 5.6 and 6.6 tCO_2eq/capita, which is a shortfall of about 0.3 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark – the smallest shortfall in the CAT analysis between NDC and benchmark among the G20 countries. Despite this, South Africa obtained a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "insufficient" in CAT's hybrid ambition benchmark.

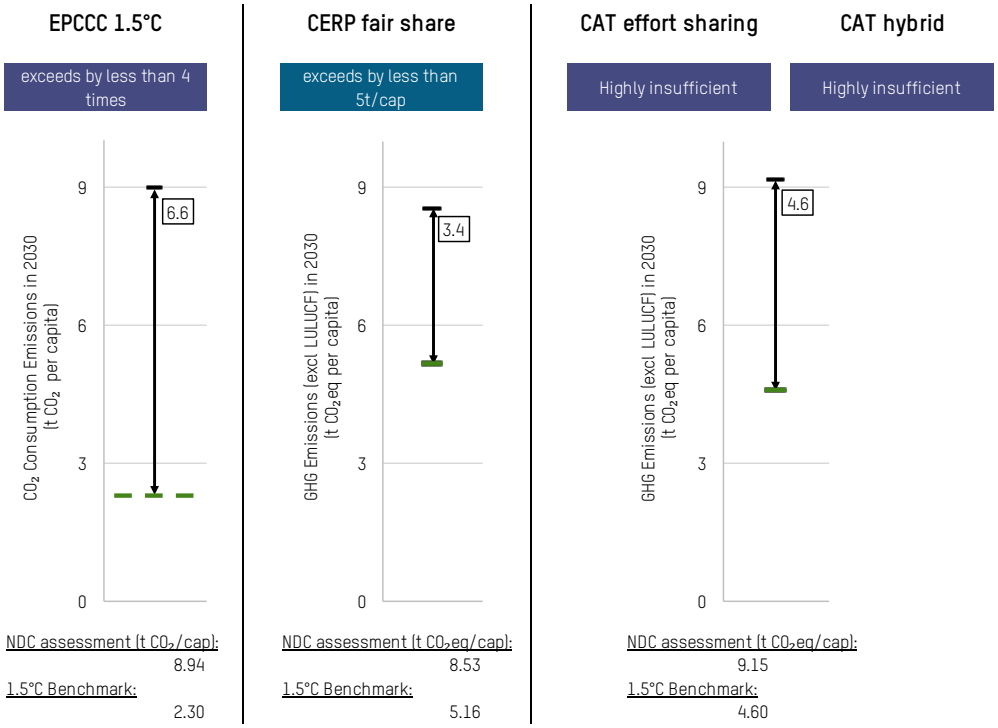
In the CERP analysis, the NDC is considered to result in 2030 emissions between 5.5 and 6.5 tCO_2eq per capita, which is actually lower than the 5.9 tCO_2eq/cap fair share benchmark – making South Africa one of only three countries that have achieved this level on any of the three approaches.

Figure 24: South Africa results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



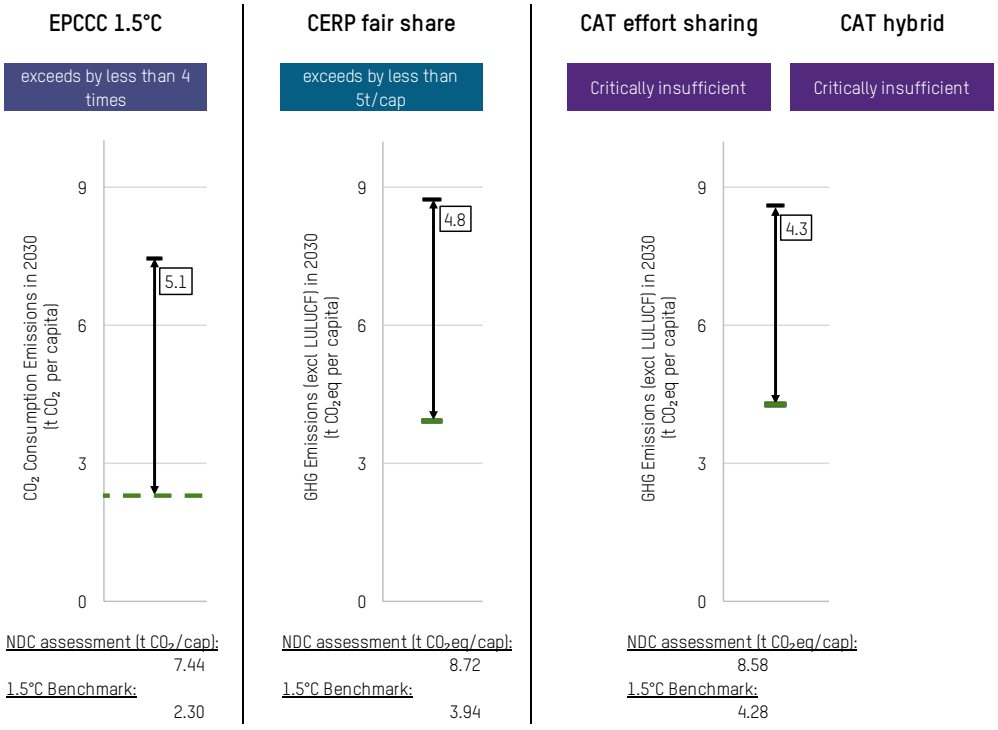
South Korea

Figure 25: South Korea results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



Türkiye

Figure 26: Türkiye results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



United Kingdom

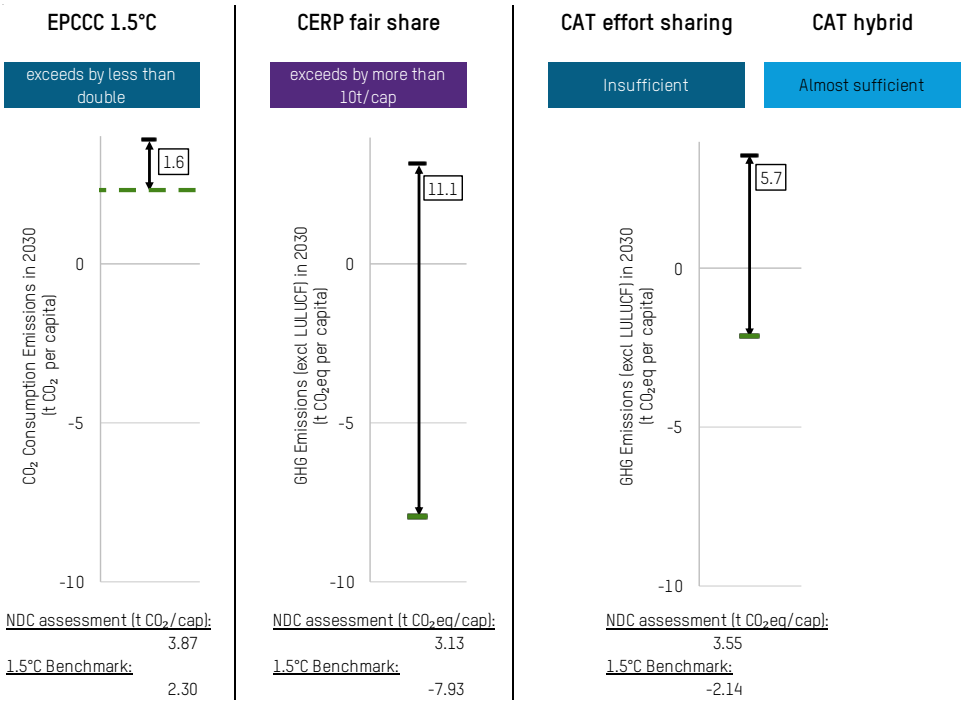
The UK's latest NDC was submitted on September 22, 2022.

In the EPCCC analysis, the UK's NDC results in consumption CO_2 emissions of 3.9 tCO_2 per capita in 2030, about twice the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions of 3.6 tCO_2eq/capita, which is a shortfall of about 5.7 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. As a result, the UK obtained a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating improves to "almost sufficient" in CAT's hybrid ambition benchmark. This makes the UK the only country among the G20 that has an "almost sufficient" CAT rating.

In the CERP analysis, the NDC is considered to result in 2030 emissions of 3.1 tCO_2eq per capita, 11.1 tCO_2/cap above the fair share benchmark.

Figure 27: United Kingdom results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



United States

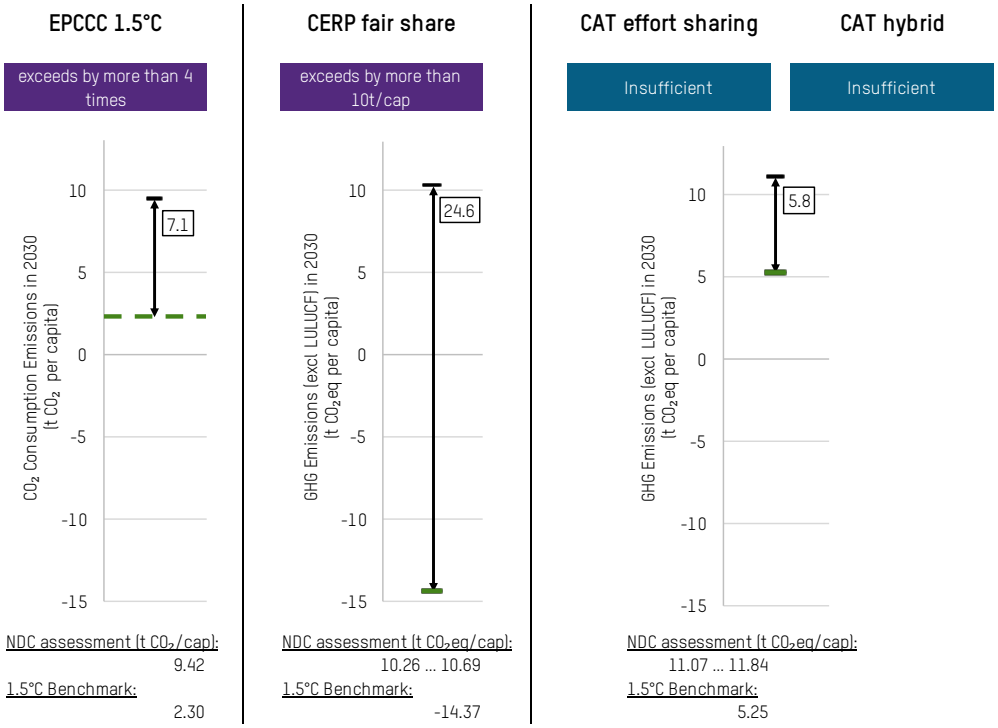
The United States' latest NDC was submitted on April 22, 2021.

In the EPCCC analysis, the US' NDC results in consumption CO_2 emissions of 9.4 tCO_2 per capita in 2030, just over four times the 1.5°C-consistent level of the equal-per-capita benchmark of 2.3 tCO_2/cap.

CAT's assessment calculates the NDC target to result in emissions of between 11.1 and 11.8 tCO_2eq/capita, which is a shortfall of at least 5.8 tCO_2eq/capita relative to CAT's "1.5°C consistent" effort sharing benchmark. As a result, the US obtained a rating of "insufficient" in the CAT effort sharing module. Combined with the other CAT assessment modules, the overall CAT rating remains at "insufficient" in CAT's hybrid ambition benchmark.

In the CERP analysis, the NDC is considered to result in 2030 emissions of between 10.3 and 10.7 tCO_2eq per capita, 24.6 tCO_2/cap above the fair share benchmark – the largest shortfall among the G20 countries compared to the benchmark levels.

Figure 28: United States results across assessment approaches. Green line segments show each approach's 1.5°C benchmark emissions level (per capita), black line segments show the emissions level implied by full mitigation NDC implementation, the number boxes show difference between benchmark and NDC level



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