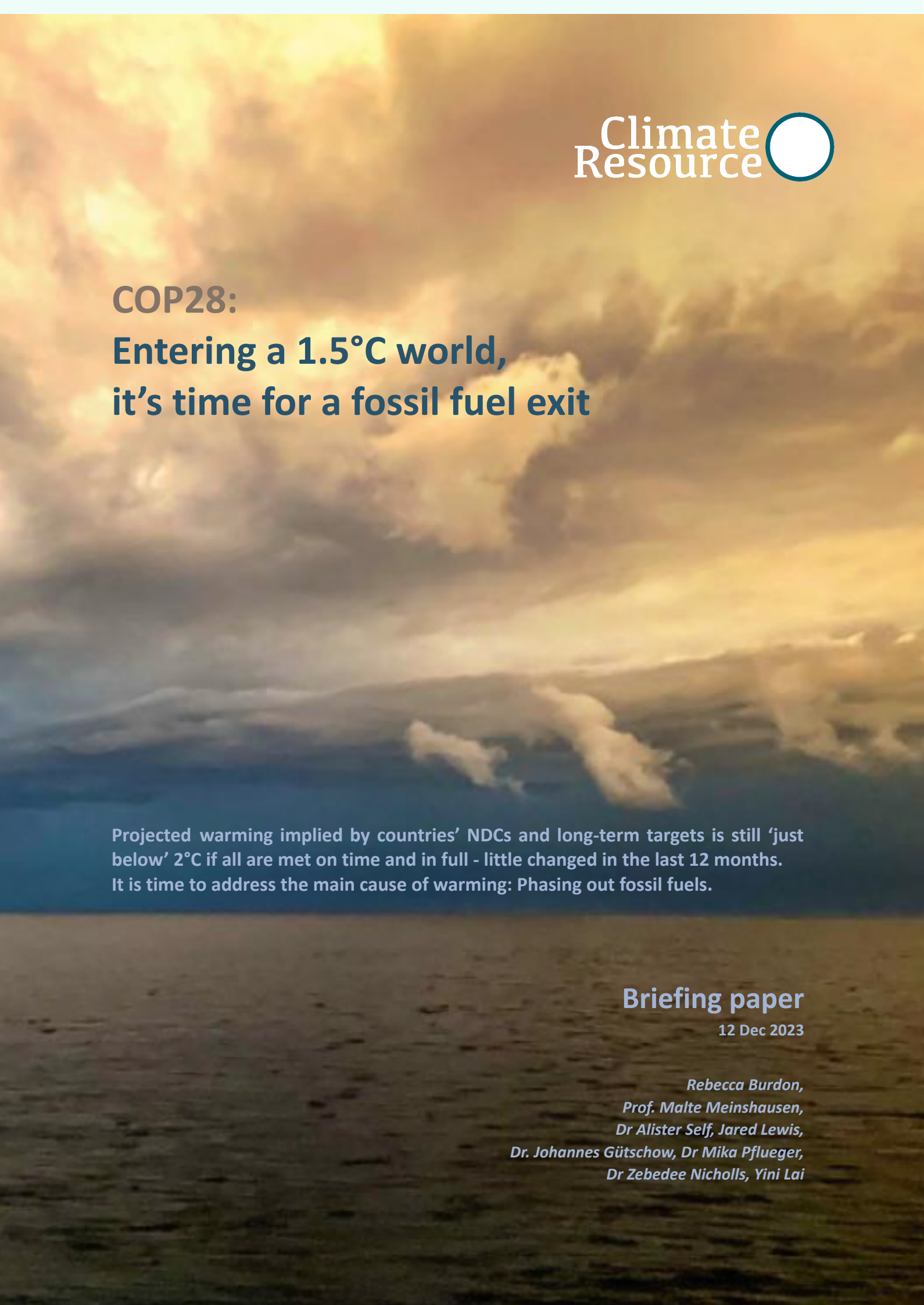

Climate Resource

COP28:
Entering a 1.5°C world, it's time for a fossil fuel exit

Projected warming implied by countries' NDCs and long-term targets is still 'just below' 2°C if all are met on time and in full - little changed in the last 12 months. It is time to address the main cause of warming: Phasing out fossil fuels.

Briefing paper

12 Dec 2023

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Image Credit

Cover photo by Malte Meinshausen, New Caledonia, 2023. The relatively calm sea represents the lack of progress on NDCs. The dark storm clouds represent the trouble ahead, if fossil fuels are not phased out soon.

Version

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Another year on:
As climate impacts intensify around the world, we are still heading for warming of only "just below" 2°C in the optimistic scenario that sees all long-term pledges fulfilled. To achieve these pledges, and to keep the "1.5°C" alive, phasing out fossil fuels is the most important step.

Countries need to overachieve their 2030 targets, phase-out coal by 2035, and phase-out all fossil fuels soon after to make mid century net-zero targets and 1.5°C pathways feasible. Combined with countries delivering on their pledge to triple renewable energy and double the rate of energy efficiency by 2030, these fossil phase-out targets would help to put the world back on track to 1.5°C.

Key points

- **Another year on:** As COP28 draws to a close, 2030 targets expressed in country submissions to the UNFCCC are still way off what is required to limit warming to 1.5°C. Our updated temperature projection only minimally lowers peak warming estimates relative to our 2022 assessment.
- **From 'what' to 'how':** COP28 complemented its focus on 'what' mitigation action should deliver (1.5°C, nearly halving global emissions by 2030 and net-zero by 2050) with the 'how': phasing out fossil fuels, phasing in renewables and doubling down on energy efficiency.
- **Tripling global renewable energy to 11 TW and doubling the annual rate of energy efficiency** improvements by 2030 is a step forward, if achieved.[1] It would more than double our estimate of renewable energy capacity reflected in 2030 NDCs (nationally determined contributions). An 11 TW target would shift renewable energy installations to levels that conform to 1.5°C aligned pathways in the scientific literature.
- **Phase-in of renewables may not drive down emissions unless complemented by a phase-out of fossil fuels.** It is essential now to agree to a commitment to phase-out fossil fuels, and to deliver on this commitment. In 1.5°C aligned pathways, electricity production from coal is down by 90% at the latest by 2035, if not 2030. All fossil fuels, including from oil and gas, need to be zero by 2050, and earlier in developed countries.
- **'Unabated' confusion.** The term 'unabated' pops up in the debate about fossil fuel phase-out. If the term *'unabated'* is left undefined, it can mean anything. A meagre reduction in emissions from fossil fuel production could be marketed as 'this fossil fuel is cleaner, i.e. not 'unabated'' - which would ignore that the bulk of emissions stems from its end-use. The only sensible definition in clearcut terms is one that amounts to something like: *'Unabated' fossil fuels still result in emissions to the atmosphere, while 'abated' fossil fuels do not.*

[1] https://energy.ec.europa.eu/system/files/2023-12/Global_Renewables_and_Energy_Efficiency_Pledge.pdf

- **Have we lost the 1.5°C target?** No, the goal of limiting end of century warming to 1.5°C remains valid, even if we overshoot and then reach it "from above". The challenge is to minimize the overshoot.
- **Are we going to see 1.5°C warming?** Yes, the IPCC AR6 Synthesis Report (2023) states that by the early 2030s, the projected long-term average is going to be (best-estimate) around 1.5°C warmer than 1850-1900. Individual years before this may be 1.5°C warmer than 1850-1900. We are already observing warming close to or at 1.5°C in 2023[2].
- **Have countries enhanced their targets in the last 12 months?** There has been limited enhancement of targets submitted to the UNFCCC and only a minimal lowering of projected temperature outcomes implied by those targets in the 12 months since COP27, although the EU and 17 other countries have submitted updated NDCs and 15 countries have updated longer-term goals in that time[3].
- **Is it 2.4°C or 1.8°C warming we are going to see if targets are met?** Best-estimate warming is still just below 2°C (we estimate 1.8°C to 1.9°C), if all 2030 and long-term targets submitted to the UNFCCC are met on time and in full and without accounting tricks or non-additional carbon offsets. If instead, countries meet only their 2030 NDCs and continue on the same trajectory in future decades - instead of increasing ambition as required to deliver their mid-century net-zero targets - our best estimate of projected warming in 2100 is between 2.1°C and 2.4°C.

[2] https://climate.copernicus.eu/copernicus-september-2023-unprecedented-temperature-anomalies

[3] The cutoff date for our last year's briefing was 5th November 2022. This briefing's cutoff date up to which NDC and LT-LEDS submissions are taken into account is 1st December 2023.

Summary

The past 12 months have seen climate impacts intensifying in regions across the world, and warming in 2023 that may be close to 1.4°C-1.5°C above pre-industrial levels.[4] Despite this, in the lead up to COP28 we saw little change in global mitigation ambition. Countries' emission reduction targets as at 1 December 2023 result in a best-estimate of warming of around 1.8°C to 1.9°C, if all NDC and long-term pledges submitted to the UNFCCC are met in full and on-time. This has barely changed from our estimates in the lead up to COP27, or following COP26 as published in Nature in April 2022 (Meinshausen et al., 2022)[5]. This 2023 projected warming assessment is lower than last year's by around 0.07°C degrees. Most of this improvement is due to more up-to-date assessments of the impact of existing policies and technology costs, and only a small share is due to an increase in the ambition of country mitigation targets.

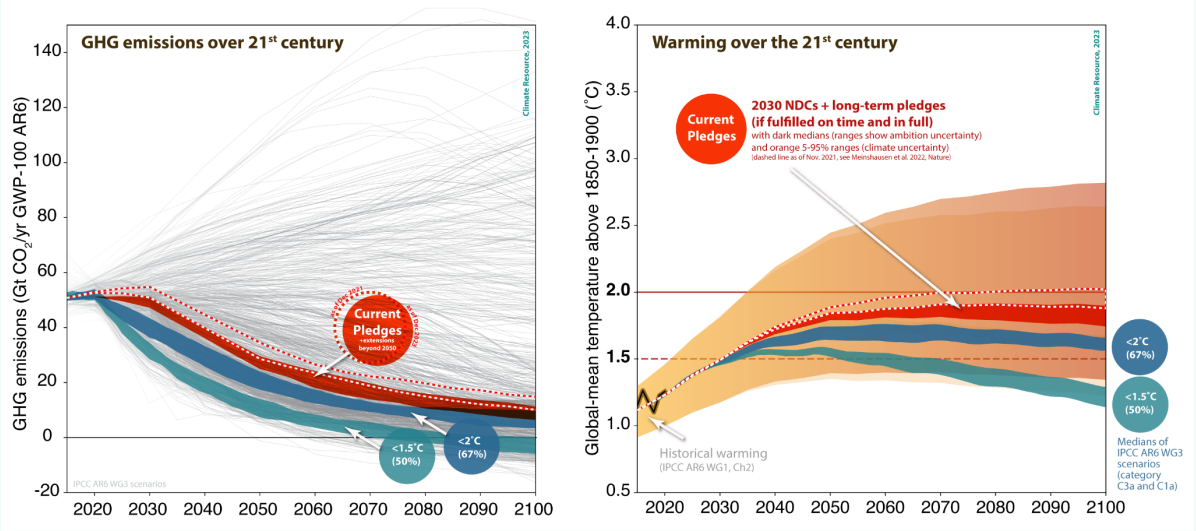

Figure 1 - Projected GHG emissions and warming over the 21st century. *Best-estimate projections following current 2030 (NDC) and long-term pledges (if they are all implemented) (red range) and including climate system uncertainty (orange ranges). For comparison, best-estimate warming for IPCC-assessed scenarios that would likely limit warming to below 2°C (67%) or limit warming to below 1.5°C (50%) by 2100 are shown in dark blue and teal ranges, respectively. Also shown are estimated GHG emission trajectories and best-estimate temperature projections at the time of COP26 (dashed lines).*

If global emissions remain on the trajectory implied by the 2030 targets in current NDCs, the best estimate of 2100 warming is quite a bit higher, i.e., 2.1°C-2.4°C[6].

There is a stark difference between the warming projection based on trajectories to 2030, and the projection that also considers the long-term targets. It highlights that the near-term targets for 2030 are not yet in line with the long-term targets, nor with an ambition of keeping warming close to 1.5°C. Of utmost importance are faster emissions reductions over the next 6 years to change the trajectory to 2030. Overachievement of many countries' 2030 targets, and stronger 2035 targets are critical to make the pathway to mid century net-zero targets feasible.

[4] https://climate.copernicus.eu/copernicus-september-2023-unprecedented-temperature-anomalies and https://berkeleyearth.org/september-2023-temperature-update/

[5] Meinshausen, M., Lewis, J., McGlade, C. et al. Realization of Paris Agreement pledges may limit warming just below 2 °C. Nature 604, 304–309 (2022). https://doi.org/10.1038/s41586-022-04553-z

[6] This range (as shown in Figure 4 and 5 below), excludes 'hot air'.

Net-zero targets and other long-term targets now adopted by over 90 countries, accounting for over 80% of global GHG (greenhouse gas) emissions, bring us substantially closer to the 1.5°C goal. Mid-century net-zero CO_2, or even better, net-zero GHG pledges are milestones for which all nations should aim as a minimum - with developed countries earlier than mid-century.

Without overachievement of current 2030 targets, the world risks failing to limit warming to around 1.5°C. Increasing the pace of decarbonisation in the next 6 years will make feasible the pace of change that is required after 2030 to meet long-term commitments and avoid warming beyond 2°C. The pledge by a coalition of 130 countries to triple renewable energy capacity and double the annual rate of improvement in energy efficiency by 2030 is an important step forward, if achieved. More important is to have those targets in the COP28 final outcome. But phasing-in renewables will only help the climate if it displaces fossil fuels. Hence, a commitment to a rapid fossil fuel phase-out is essential in order to reduce emissions. To move towards 1.5°C consistent pathways, the world needs to commit to delivering:

- ***Phase-out of coal in the 2030s - with at least a 90% reduction by 2035 at the latest.***
- ***Phase-out of oil and gas by 2050, and earlier in high-income economies.***

This set of complementary targets and supporting policies would play a pivotal role in moving the world towards a 1.5°C aligned pathway. It would go a long way towards closing the 'emission gap' between aggregate emissions in 2030 that will result from nationally determined contributions (NDCs), and cost-efficient pathways towards 1.5°C.

Climate Resource temperature estimates outlined in this brief are broadly consistent with analyses recently provided by the UNFCCC 2023 NDC Synthesis Report[7], the IEA World Energy Outlook 2023[8], Climate Action Tracker[9] the UNEP Emissions Gap Report 2023[10]. For the public and decision makers, distinguishing between the temperature projections that take long-term targets into account from those that do not is a challenge when interpreting the various temperature ranges reported in the media. To aid understanding, we provide a comparison across the various studies with explicit separation by targets considered and uncertainties reported (Figure 7).

[7] https://unfccc.int/ndc-synthesis-report-2023
[8] https://www.iea.org/reports/world-energy-outlook-2023
[9] https://climateactiontracker.org/documents/1187/CAT_2023-12-05_GlobalUpdate_COP28.pdf
[10] https://www.unep.org/resources/emissions-gap-report-2023

1. Introduction

This briefing provides an update of temperature projections - taking into account NDCs and climate pledges as of 1 December 2023. We principally use the same methodology as in our previous assessments (Figure 2)[11].

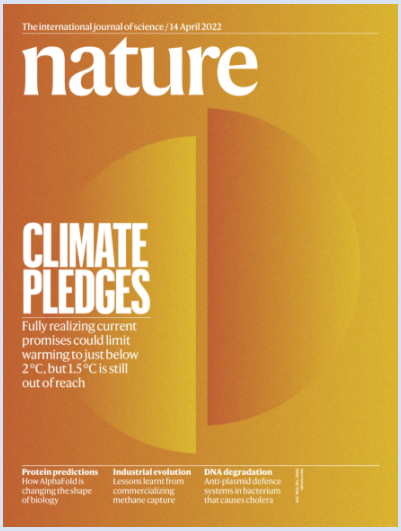

Figure 2 - *Nature cover story as of 15th April 2022, providing methodological details and a comparison point for climate pledges as of Nov. 2021. In short, not much has changed since. See https://www.nature.com/articles/s41586-022-04553-z*

The methodology in this briefing is largely the same, but incorporates updates to:
1) the reference scenarios - we now draw on NGFS Phase 3 scenarios to reflect more up to date assessments of the impact of current policies and technology costs (instead of SSP5-baseline)[12], and
2) compare the warming projections against the IPCC AR6 WG3 scenarios (instead of SR1.5 scenarios).

2. Projected temperature rise if countries achieve targets submitted to the UNFCCC

Updates to country targets submitted to the UNFCCC in the last 12 months have not moved the world materially closer to limiting warming to 1.5°C: We analyse the NDCs and LT-LEDS (long-term low-emissions development strategies) submitted, and the implications for emissions of 196 countries[13], plus international aviation and shipping. We provide detailed country-by-country assessments online at: https://www.climate-resource.com/tools/ndcs.

Our optimistic best case is stagnant at about 1.8°C-1.9°C. Since our November 2022 update, 17 Parties plus the EU have submitted formal updates to NDCs[14]. 15 parties have submitted updated LT-LEDS. As at 1 December 2023, countries' emission reduction targets result in a best-estimate of warming of around 1.8°C to 1.9°C - *if* all NDCs and long-term pledges submitted to the UNFCCC are

[11] The methodology with updated reference scenarios is described at https://www.climate-resource.com/tools/ndcs/methods
[12] See methodology description at: https://www.climate-resource.com/tools/ndcs/methods
[13] 193 Parties to the Paris Agreement, and three countries that have not yet ratified the Agreement: Iran, Libya and Yemen.
[14] The cut-off date for our last year's briefing was 5th November 2022. The cut-off date for this briefing for NDCs and LT-LEDS was 1 December 2023.

met in full, and on-time. This has barely changed from our estimates in the lead up to COP27, or following COP26 as published in Nature in April 2022 (Meinshausen et al., 2022)[15] (see Figure 3a and 3b below). This 2023 projected warming assessment is lower than last year's by around 0.07°C degrees. Most of this improvement is due to more up-to-date assessments of the impact of existing policies and technology costs, and only a small share is due to an increase in the ambition of country mitigation targets.

The world has seen little progress towards more ambitious mitigation targets in the past two years, despite intensifying climate impacts around the world. Commitments made in the lead up to and at COP26 delivered an historic moment: For the first time, in November 2021 the aggregate effect of the combined pledges by 193 countries delivered a best-estimate of projected peak warming of 1.9°C-2.0°C with around a 50% chance. In contrast, at the time of the Paris Agreement in 2015, the best estimate of peak warming was above 3°C.

The critical changes in emissions needed this decade are not yet evident. Total GHG emissions reached a new record high in 2022.[16] Significant new policies have been implemented in the past 12 months, including the Inflation Reduction Act (USA)[17], and the Carbon Border Adjustment Mechanism (EU)[18]. The IEA's World Energy Outlook 2023 flagged that global energy-related CO_2 emissions could peak by 2025 or earlier under current policies[19]. It also noted that under current policies, emissions remain on a path to around 2.4°C of warming.

Faster reductions between 2023 to 2030 and 2035, delivering a more consistent rate of reduction in emissions to net-zero, are critical if the world is to limit end of century warming to 1.5°C. If emissions remain at current levels, the 1.5°C remaining carbon budget estimated in the IPCC Sixth Assessment Report (AR6) (i.e. 500 $GtCO_2$ eq from the beginning of 2020) would be almost completely used by 2030.

The Climate Resource temperature projections hinge on the assumption that the targets submitted to the UNFCCC are achieved on time and in full. Effective climate, energy and land use policies and actions are required to deliver these targets. Many are not yet backed by policy. All the conditional NDCs also require appropriately scaled-up climate finance and adequate support in order to be implemented.

[15] Meinshausen, M., Lewis, J., McGlade, C. et al. Realization of Paris Agreement pledges may limit warming just below 2 °C. Nature 604, 304–309 (2022). https://doi.org/10.1038/s41586-022-04553-z

[16] Total GHG emissions excl. LULUCF, as provided in the data product PRIMAP-hist that we maintain and make available at: https://primap.org/

[17] available at: https://www.epa.gov/green-power-markets/summary-inflation-reduction-act-provisions-related-renewable-energy

[18] https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

[19] https://www.iea.org/reports/world-energy-outlook-2023

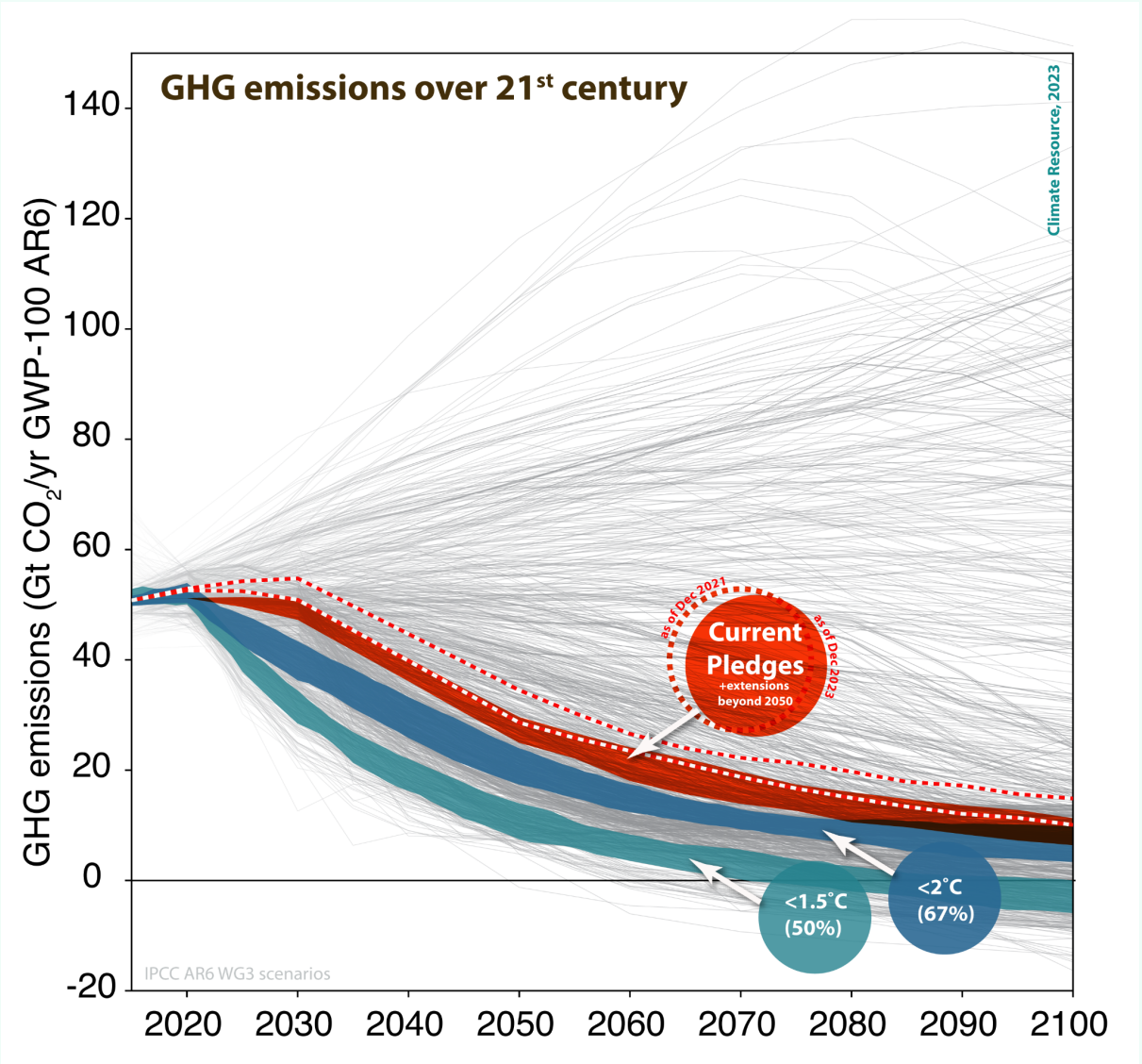

Figure 3a - GHG emissions due to NDCs and long-term targets. *Global GHG emissions estimated based on the NDCs and long-term targets submitted to the UNFCCC as of 1 December 2023 compared to 1 December 2021 (see Meinshausen et al., 2022), with a sensitivity case considering full implementation of 2030 NDC targets (lower end of the red band) and only unconditional targets (upper end of the red band). The dark blue and teal bands show the median ranges for the IPCC AR6 WG3 scenarios, classified as <2 °C with a likely (67%) chance and <1.5 °C with no or low overshoot with a 50% chance by 2100, respectively. The thin grey GHG emissions are the scenarios analysed in IPCC AR6 Scenario Database.*[20]

[20] The data for the figures are freely available for reproduction here (Creative Commons Attribution Non Commercial Share Alike 4.0 International):
https://data.climateresource.com.au/ndc/20231211-briefing/20231201c_TP_scenario_summary.csv

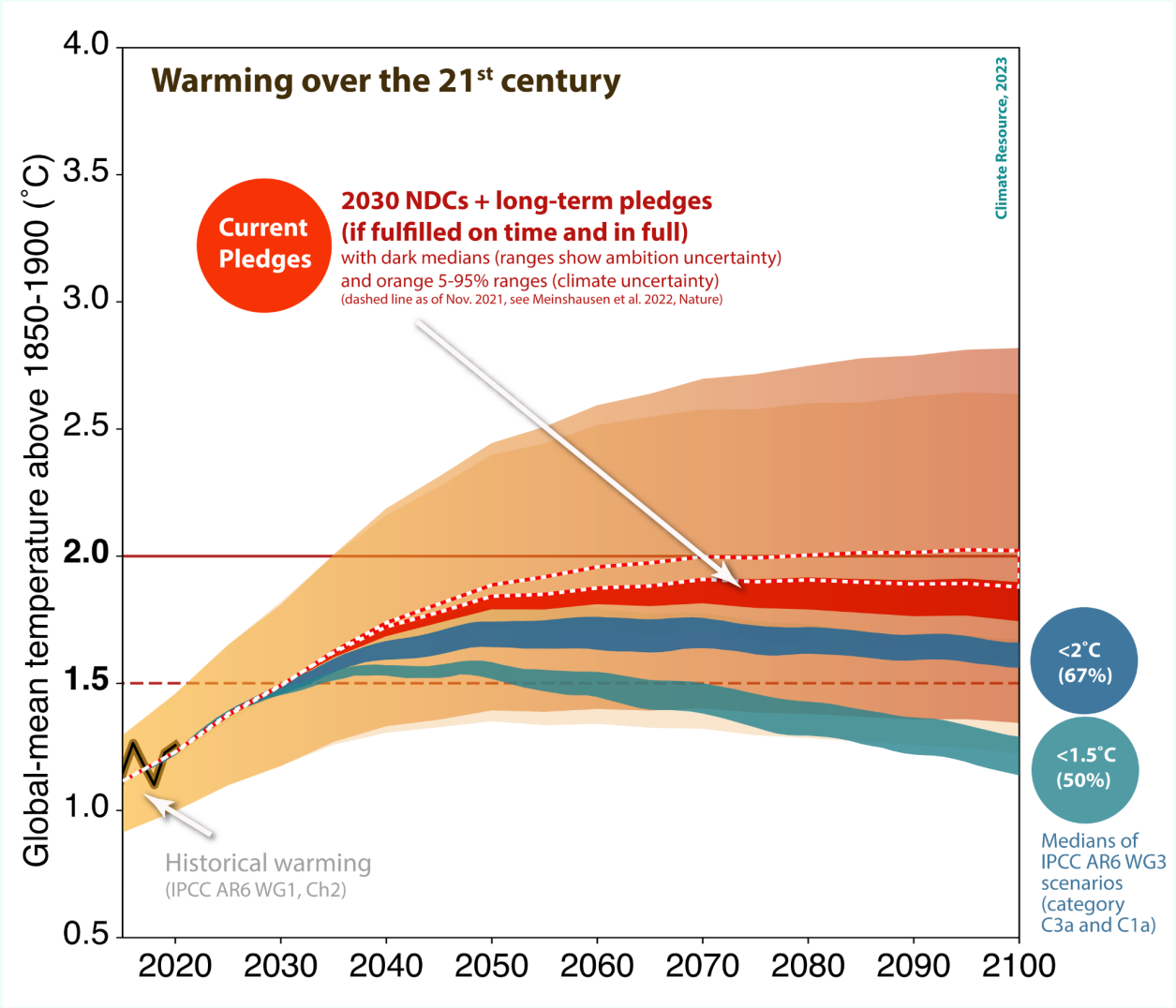

Figure 3b - Warming due to NDCs and long-term targets. *Global mean temperature projections based on all officially submitted NDCs and long-term targets as of 1 December 2023 compared to end November 2021 (see Meinshausen et al., 2022), with a sensitivity case considering full implementation of 2030 NDC targets (lower end of the red band) and only unconditional targets (upper end of the red band) in addition to the long-term pledges. In the full implementation case, the pledges have a roughly 70% chance of staying below 2°C, whereas when only considering unconditional 2030 pledges and the long-term targets, there is around a 55% chance. For 1.5°C, the full implementation case still has a 85%-90% likelihood of exceeding with best-estimate warming in 2100 at around 1.75C (see Table 1 below). The dark blue and teal bands show the median ranges for the IPCC AR6 WG3 scenarios, classified as <2°C with a likely (67%) chance and <1.5°C with no or low overshoot with a 50% chance by 2100, respectively.*[21]

[21] The data for the NDC pathways are freely available for reproduction here (Creative Commons Attribution Non Commercial Share Alike 4.0 International): https://data.climateresource.com.au/ndc/20231211-briefing/20231201c_TP_scenario_summary.csv

When ignoring any long-term targets, the projected temperatures are well beyond 2°C. We estimate peak warming of 2.1°C-2.4°C based only on 2030 pledges and when excluding 'hot air', similar to the headline numbers of the UNFCCC 2023 Synthesis Report, UNEP 2023 Emissions Gap Report etc. (as shown in Figure 4 and 7). This is higher and a wider range than the 1.8-1.9°C warming we derive when taking into account both NDCs and long-term targets. This difference is crucial and gets overlooked when only comparing headline numbers.

- **The reason our 2030-only warming estimates are higher** is that the 1.8-1.9°C estimate includes 94 quantified long-term targets for either 2050, 2060 or 2070, now covering approximately 82% of global emissions. Many of these are net-zero targets, so emissions are substantially lower than emissions derived based on extending the 2030 levels.[22]
- **The reason that the 2030-only warming estimates have a wider range and are more uncertain** is that the projected temperature rise resulting from 2030 commitments is subject to larger uncertainties. That is largely because one has to extrapolate emissions by 70 years beyond 2030 to derive warming estimates. The 2030 emission levels implied by targets are also uncertain: Many non-Annex 1 countries attach conditions to their 2030 pledges. Some also specify targets as a reduction below an unstated business as usual (BAU) reference scenario or an emissions intensity target in which the GDP projection is unknown or uncertain.

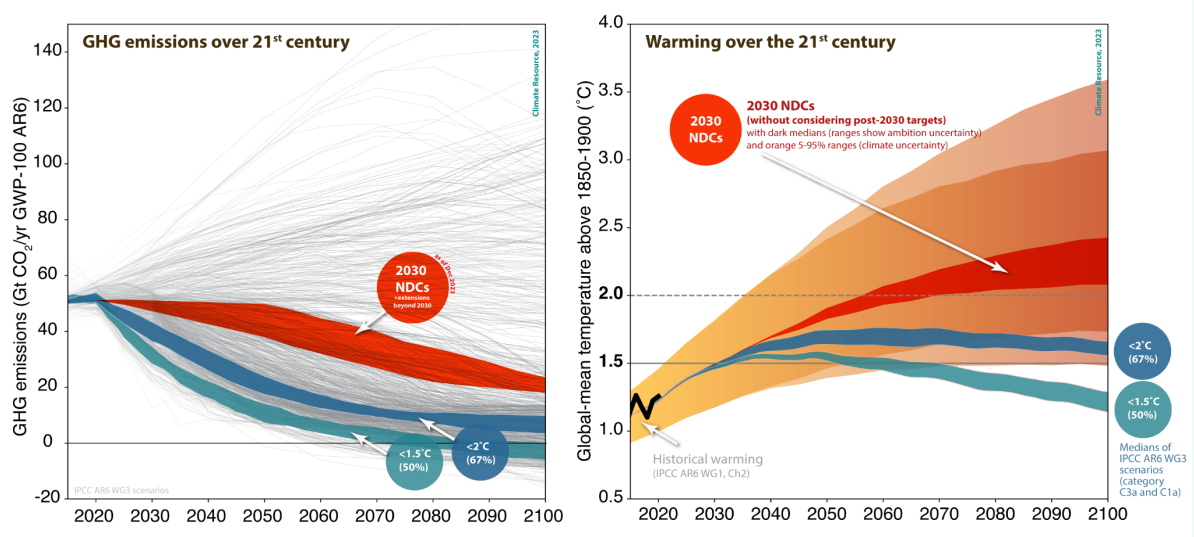

Figure 4 - Global GHG emissions and global-mean temperature projections *based only on 2030 NDCs and emission extrapolations for the period from 2030 to 2100. These result in a wider range and higher-level of warming compared to projections that also consider longer-term commitments. Global mean temperature projections based on all officially submitted NDCs of 1 December 2023 (red ranges) are shown. The lower end of the shown ranges is a sensitivity case considering the best-case scenario of a full implementation of NDC targets and the upper end is (the top end of) an implementation that only considers unconditional 2030 NDC targets. For comparison, the right panel shows the IPCC AR6 WG3 scenarios that limit warming to below 2°C with a likely chance and those that limit warming to around 1.5°C with a low overshoot before returning below 1.5°C before 2100[23].*

[22] This estimate is dependent on the underlying emission source one chooses. Officially reported data suggests a lower fraction of global emissions being covered, such as 79% as reported in the UNFCCC NDC Synthesis Report, 2023 (available at: https://unfccc.int/ndc-synthesis-report-2023).

[23] The data for the NDC pathways are freely available for reproduction here (Creative Commons Attribution Non Commercial Share Alike 4.0 International): https://data.climateresource.com.au/ndc/20231211-briefing/20231201c_TP_scenario_summary.csv

3. Renewable energy phase-in, energy efficiency, and fossil phase-out - and how they conform to 1.5°C pathways

The pledge to decisively phase-in renewables is a step in the right direction.
The pledge to triple global renewable energy and double the annual rate of energy efficiency improvements by 2030 is a step forward, if achieved. The tripling of renewable energy capacity relative to today's levels (~3.6TW) would deliver 11 TW by 2030. This would more than double our estimate of renewable energy capacity that is implied by 2030 NDCs. An 11 TW renewable installed capacity would be approximately aligned with 1.5°C aligned pathways in the scientific literature, although the more recent 1.5°C consistent scenarios even imply slightly higher renewable capacities in 2030 of 12 TW and above[24].

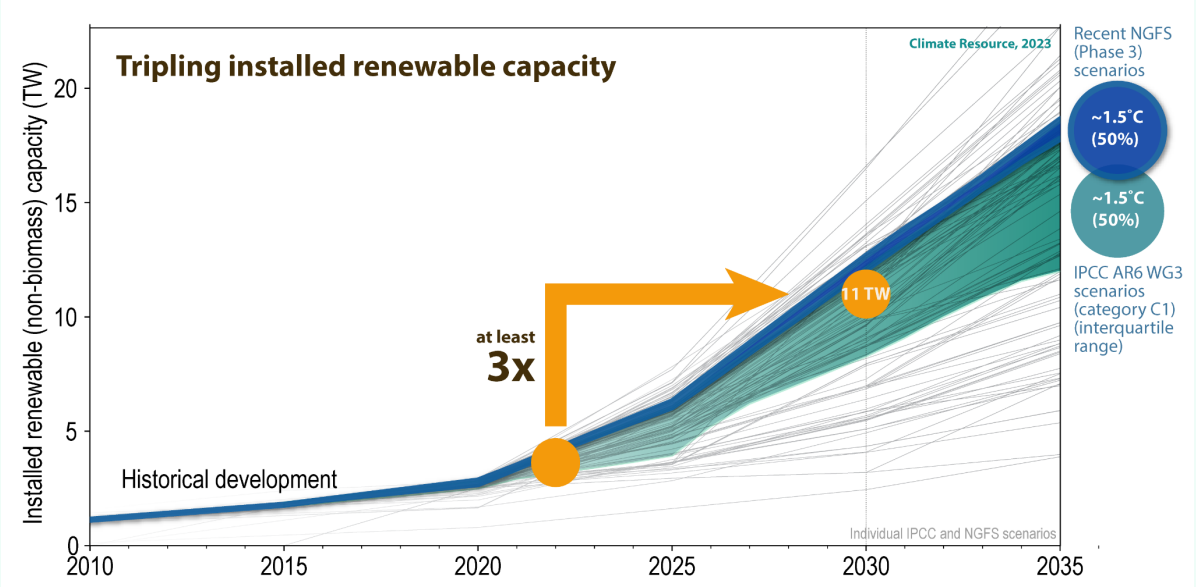

***Figure 5** - Installed renewable (non-biomass) capacity in 1.5°C consistent scenarios for the IPCC AR6 WG3 database and recent NGFS scenarios. Thanks to the recent success of solar PV and wind deployment, the more recent 1.5°C scenarios project around 12 TW of installed capacity by 2030.*

[24] See e.g. NGFS scenarios, Phase 3, available here: https://zenodo.org/records/7085758

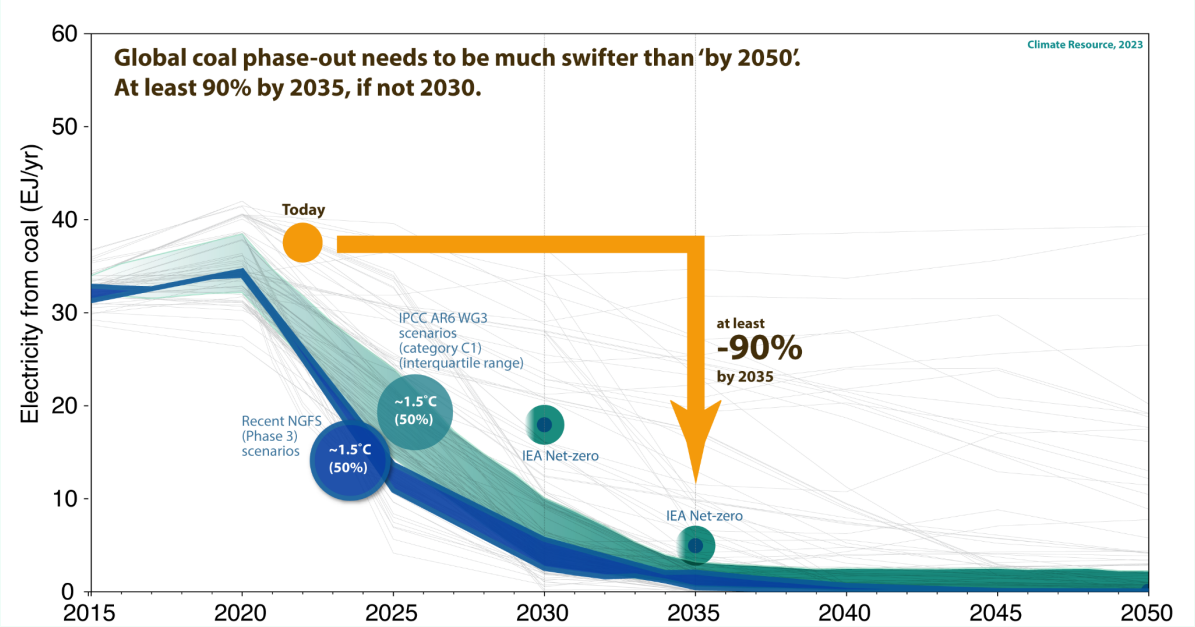

Figure 6 - Electricity from coal generation. *In addition to phasing out of fossil fuels (oil, coal and gas) to zero levels by 2050, the timeline for coal phase out is much earlier. In 1.5°C consistent scenarios, electricity production from coal is down by ~90% or more in 2030 or 2035 in case of the IEA Net-zero scenario.*

From 'what' to 'how'[25]: Underpinning NDCs with phase-in, phase-out and energy efficiency targets. With the stagnating progress towards stronger NDCs, COP28 success will be measured by whether a decisive agreement is reached on the phase-out of fossil fuels. This is the key additional pillar to the pledge on renewable energy capacity and energy efficiency - needed for these complementary targets to help close the emissions gap and deliver a more feasible pathway to 1.5°C. On 10 December 2023, the IEA judged that COP28 pledges so far close one-third of the gap towards the IEA's Net-zero emission scenario[26].

[25] see e.g. speech by UN Climate Change Executive Secretary Simon Stiell, available at https://unfccc.int/news/cop28-must-mark-a-shift-from-the-what-to-the-how

[26] https://www.iea.org/news/iea-assessment-of-the-evolving-pledges-at-cop28

4. Is the 1.5°C target lost?

Our best-estimate remains that we will see 1.5°C warming, or even 1.6°C - even in the strongest mitigation scenarios. Last year, we wrote that "There is a good chance that we are going to see an El Nino year this decade that is going to push global-mean and annual-average warming for the first time beyond 1.5°C in a single year". Unfortunately, 'that year' could already be this year, 2023[27]. By the early 2030s, the IPCC's AR6 best estimate is that we will reach 1.5°C over a 20-year average in all scenarios. Adaptation efforts have to assume that 1.5°C warming is the absolute minimum warming we are going to face. That is not a new insight. Even at the time of the Paris Agreement, when 1.5°C entered the negotiations, the UNEP Emissions Gap Report, for example, classified emission scenarios as 1.5°C scenarios if they stayed around 1.5°C warming (even with the potential for a small overshoot) and then returned below 1.5°C by the end of the century.

The 1.5°C target is not lost, but we seem to be choosing a less cost-efficient and higher climate impact path to achieve it. In fact, as Art. 2 of the Paris Agreement is referred to as one temperature goal (see e.g., Art. 4.1, where it says "In order to achieve the long-term temperature goal set out in Art. 2, …"), the possibility of a slight overshoot of 1.5°C is built into the Paris Agreement's Art. 2 itself. Even if we cannot avoid 1.6°C warming, the 1.5°C target is not lost and not less relevant. We can still achieve lower end of century temperatures after the peak and get to below 1.5°C warming by 2100. Once we are at 1.6°C, we have two choices: stay at 1.6°C or above, or return back down. Returning to below 1.5°C will avoid many reversible impacts relative to a counterfactual in which temperatures remain higher. A path that limits warming to 1.5°C "from above" (i.e. after a temporary overshoot) has higher climate impacts and risks higher costs: it tends to be more cost effective to avoid emissions in the first place rather than removing CO_2 from the atmosphere in later decades via negative emissions. But the 1.5°C goal is not lost.

Every tonne emitted, every bit of warming counts. We should keep in mind that all our quantifications rest on our current level of knowledge of how the Earth System is going to react to these unprecedented levels of emissions. If the Earth system responds with more warming to our GHG emissions than we expect (and as some of the 'hotter' climate models in CMIP6 suggest), then we will shoot past 1.5°C and possibly also 2°C based on the world's historical levels of fossil fuel burning alone. The climate system uncertainty range is substantial, as shown in our 5-95% uncertainty ranges around the best-estimate temperature projections (orange ranges in Figure 1, 3b and 4). Every ton of emissions adds to future damage and every bit of warming will go hand in hand with more dire climate change impacts. Given that we have the technical and economic options to reduce our emissions now, the best insurance policy against high future impacts is to use these options. No matter what temperature we end up at, every tonne emitted increases warming and every bit of warming counts.

[27] https://berkeleyearth.org/will-2023-be-the-first-year-above-1-5c/

5. Comparison of temperature projections

Several estimates of the temperature rise implied by current pledges and climate policies have been published in recent weeks that include 2023 updates of countries' NDCs and long-term targets. We compare these recent studies to shed light on the reasons for differences. When comparing 'apples' with 'apples', all the estimates are similar. That is not the case when comparing the headline numbers, as they can refer to very different scenarios, warming percentiles or underlying key assumptions.

In summary, when comparing the IEA WEO[28], the UNEP Emissions Gap Report[29], the UNFCCC Synthesis Report[30], the Climate Action Tracker study and our own, the studies are very consistent. Differences in headline numbers mainly arise from different scenarios being reported or different warming ranges - with the strongest difference being the range of 'ambition ambiguity', i.e. to what extent different scenario extensions are explored. The 2023 UNEP Gap report explores a very wide range of scenario extensions compared to the other studies, resulting in a wide range of 'best-estimate projections' that are also substantially wider than the 2022 UNEP Gap report's estimates (and a bit higher) (Figure 7).

Whether long-term targets are included or not makes a big difference. Some, including our own or e.g. the Climate Action Tracker (Dec 2023) contain projections of the temperature rise associated with the achievement of all climate pledges, including the longer-term pledges and optimistically not filtering out any pledges that are not enshrined in more robust legal frameworks but are 'just' submitted as LT-LEDS to the UNFCCC. All organisations' projections are broadly consistent with our assessment for this 'optimistic' quantification in case that all the pledges are fulfilled on time and in full and without any accounting tricks. Some are even a bit lower than our headline number of 1.8°C-1.9°C. The reason some are lower is that Climate Resource assessment only considers targets that have been officially submitted to the UNFCCC in the form of either an NDC or a LT-LEDS submission (Figure 7). Additional net-zero pledges are taken into account by the IEA and CAT. An additional small cooling effect is also part of the UNEP Gap report numbers, as that report uses a different climate emulator compared to all the other studies shown. Likewise, there is a difference between announced net-zero targets and officially submitted long-term targets (whether net-zero or not). The UNEP Emissions Gap Report (2023) for example included a scenario that only considers net-zero targets under strict selection criteria.

[28] https://www.iea.org/reports/world-energy-outlook-2023
[29] https://www.unep.org/resources/emissions-gap-report-2023
[30] https://unfccc.int/ndc-synthesis-report-2023

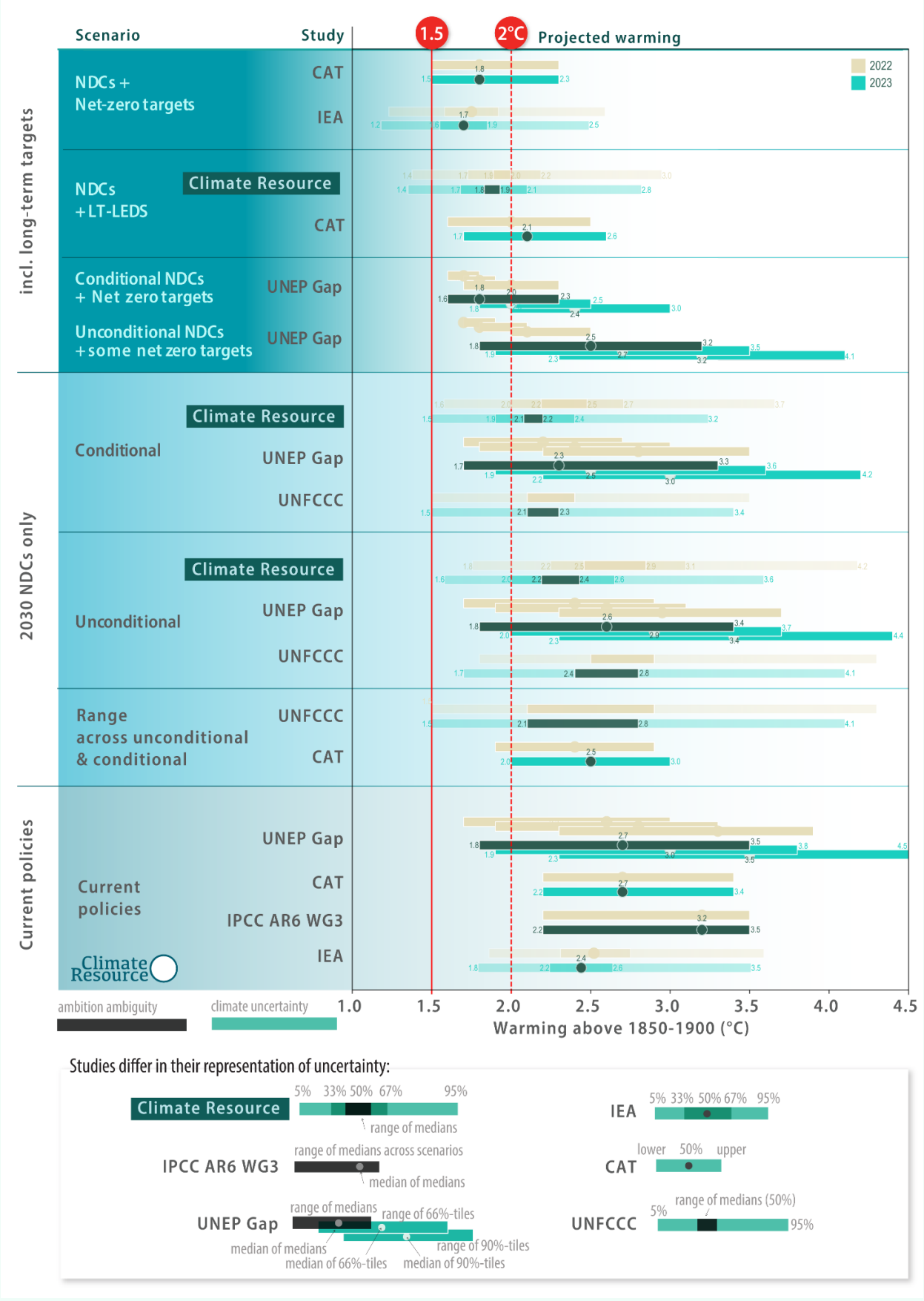
Scenario
Study
1.5
2°C
Projected warming
2022
2023
incl. long-term targets
NDCs + Net-zero targets
CAT
IEA
NDCs +LT-LEDS
Climate Resource
CAT
Conditional NDCs + Net zero targets
UNEP Gap
Unconditional NDCs +some net zero targets
UNEP Gap
2030 NDCs only
Conditional
Climate Resource
UNEP Gap
UNFCCC
Unconditional
Climate Resource
UNEP Gap
UNFCCC
Range across unconditional & conditional
UNFCCC
CAT
Current policies
Current policies
UNEP Gap
CAT
IPCC AR6 WG3
IEA
Climate Resource
ambition ambiguity
climate uncertainty
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Warming above 1850-1900 (°C)
Studies differ in their representation of uncertainty:
Climate Resource
5% 33% 50% 67% 95%
range of medians
IPCC AR6 WG3
range of medians across scenarios
median of medians
UNEP Gap
range of medians
range of 66%-tiles
median of medians
median of 66%-tiles
range of 90%-tiles
median of 90%-tiles
IEA
5% 33% 50% 67% 95%
CAT
lower 50% upper
UNFCCC
range of medians (50%)
5%
95%

Figure 7 *- Comparison of our warming projections with key recently published studies for different scenarios. Shown are the IPCC AR6 WG3 estimates for current policy implications (as of end of 2020)[31], the UNEP Emission Gap report 2023[32], the IEA WEO 2023 report[33], the Climate Action Tracker assessment as of December 2023[34], and the UNFCCC NDC Synthesis Report[35] as of November 2023. Note that the uncertainty representation of both the ambition ambiguity (black ranges) and climate uncertainty (teal ranges) is different in the different studies (see legend)[36]. Studies also vary in terms of their cut-off dates, the number of countries they explicitly analyse[37], the set of pledges they take into account, or whether they "cap" pledges at "current policy" or reference emission projections (i.e., include "hot air")[38]. All shown studies (except the UNEP Gap report this year) use the MAGICC7 model (see live.magicc.org) to produce the reported climate projections and uncertainties[39]. For most of the analysed scenarios shown here, the distinction between peak and 2100 temperatures does not matter, but studies differ in terms of their reported headline numbers.[40]*

[31] See IPCC AR6 WG3 SPM section C1.3. The reported range is the range of the medians across all scenarios that quantify the trend from currently implemented climate policies.

[32] The UNEP Emission Gap report is available at https://www.unep.org/resources/emissions-gap-report-2023. The headline numbers are the 66% climate percentiles in the UNEP gap report. For comparability with other studies, we here show the medians (black ranges) and also the upper end of the 90% climate uncertainty range, as provided in Table 4.4 of the UNEP Emission Gap report 2023.

[33] See Figure 4.1 in IEA WEO 2023, available at: https://www.iea.org/reports/world-energy-outlook-2023

[34] The Climate Action Tracker Dec 2023 Assessment is available here: https://climateactiontracker.org/publications/no-change-to-warming-as-fossil-fuel-endgame-brings-focus-onto-false-solutions/

[35] The UNFCCC Synthesis Report (2023) provides temperature assessment in Paragraph 151 and Footnote 60.

[36] If ambition ambiguity is reported for a particular study, we report the 5% or 33% percentiles (if available) that are corresponding to the more ambitious end of the scenarios, and likewise the upper 67% and upper 95% percentiles, corresponding to the less ambitious quantification provided.

[37] Our study analyses 193 member countries of the UNFCCC (196 countries in total), as presented on https://www.climate-resource.com/tools/ndcs. Other studies focus on a subset of key countries.

[38] "Hot air" refers to the amount of emissions that a quantified NDC pledge for 2030 sits above a reference scenario projection or a "current policy" implementation projection. From an optimistic point of view, this 'hot air' can be termed 'overachievement' of the pledged climate targets. Most often however, the case is rather that pledged targets are substantially higher than reasonable 'no additional climate policy' scenarios, even though existing climate policy in a particular country is not very ambitious. The CAT and UNEP Gap report and our own Climate Resource estimate are studies that exclude 'hot air' in one form or another, whereas the UNFCCC Synthesis report for example takes NDC pledges at face value without "capping them" to remove hot air.

[39] The UNEP Gap report uses the FaIR model which is closely comparable, yet possibly 0.1°C cooler for the low mitigation scenarios. See a comparison between MAGICC7, FaIR and other emulators as well as the IPCC assessed ranges in Cross-Chapter Box 7.1 in Chapter 7 of the IPCC AR6 WG1 report, available at: https://www.ipcc.ch/report/ar6/wg1/.

[40] The reason that peak and 2100 global-mean surface air temperatures are closely comparable is that emission extensions beyond 2050 generally do not assume (strongly) negative emissions, if any. Thus, peak temperatures are in most cases identical or very close to 2100 temperatures. The above table shows peak global-mean temperatures over the 21st century for Climate Resource, 2100 temperatures for IPCC AR6 WG3; 2100 temperatures (presumably) for the UNEP Gap report ("Emissions over the course of the twenty-first century"); 2100 temperatures for the IEA; 2100 temperatures for CAT; and peak temperatures of the UNFCCC NDC Synthesis Report.

"Current policy" still leads to warming well beyond 2°C, and 2023 updates are only lower than 2022 estimates by about or less 0.1°C, if at all. The IPCC AR6 WG3 estimate (with an early cut-off date of 2020) is on the high side at 3.2°C (here shown as 'unchanged' compared to 2022). The comprehensive IEA WEO (2023) STEPS scenario with its central estimate of 2.4°C warming is 0.1°C lower than previous' year's IEA estimate and somewhat lower than the estimates by the CAT and the UNEP Gap report which both sit at 2.7°C (although the latter features a larger uncertainty range) (see bottom of Figure 7 above).

For 2030 unconditional pledges (not taking into account longer term pledges), UNEP (2023) reports a comparatively wide range (1.8°C-3.4°C) but a median of 2.6°C, which is at the midpoint of the range reported by the UNFCCC (2.4°C-2.8°C). Climate Resource estimates a lower median, between 2.2°C-2.4°C). For 2030 conditional pledges (also not taking into account longer term pledges), the assessed ranges are more closely aligned. The UNFCCC (2.1°C - 2.3°C), Climate Resource (2.1°C - 2.2°C) and the UNEP Gap have similar central warming estimates (UNEP Gap estimates a central 2.3°C, although with a wide range between 1.7°C-3.3°C)

When longer-term pledges are also taken into account, UNEP reports a large range of 1.8°C-2.5°C across its assessment of conditional and unconditional NDCs as it uses a 'strict criteria' to assess net-zero pledges. These assessments are higher than last year's UNEP Gap report, which estimated a 1.7°C rise under both conditional and unconditional scenarios, largely due to a change in methodology. Our Climate Resource assessment projects 1.8°C (based on conditional NDCs, excluding hot air, and an ambitious interpretation of ambiguous components of officially submitted pledges) to 1.9°C (unconditional NDCs, including hot air, and a low ambition interpretation of ambiguous pledges). The IEA WEO (2023) estimate is the lowest, projecting 1.7°C in its Announced Pledges Scenario - possibly consistent with a comprehensive energy-system modelling approach by IEA[41].

The extensions are a key source of uncertainty. A key difference across the studies are the approaches, methodologies used to extend emissions beyond the point that targets are defined. That is also the explanation for different uncertainty ranges, with the UNEP Gap report in particular showing a wide range of projected temperature results even for the same percentile warming estimate. More detail can be found in the underlying studies[42].

[41] https://www.iea.org/reports/global-energy-and-climate-model/announced-pledges-scenario-aps

[42] See e.g. the UNEP Gap report, available at: https://www.unep.org/resources/emissions-gap-report-2023 or the Climate Action Tracker, available at: https://climateactiontracker.org/publications/no-change-to-warming-as-fossil-fuel-endgame-brings-focus-onto-false-solutions/

6. Detailed results and methods

Here, we provide more methodological detail to our warming assessments as well as the detailed scenario results. The scenario results correspond to key scenarios shown in the Extended Data Table 2 in our Nature April 2022 publication.[43]

Data availability: The emission data for individual country pledges is provided here: climate-resource.com/tools/ndcs - free for re-use with a Creative Commons Attribution Non Commercial Share Alike 4.0 International license. GHG emissions and temperature quantifications from the Figures are also available, free for any reproduction with attribution to Climate Resource[44]. Our conditional, high ambition and unconditional, low ambition quantification of the NDC and long-term pledge pathways (as of 1st December 2023) are also available in a more interactive mode[45].

Climate calculations: This analysis uses probabilistic climate model emulator projections in line with the IPCC AR6 WG1 report released in August 2021, specifically using the climate emulator MAGICC7, available at live.magicc.org, which is maintained by scientists and programmers at Climate Resource, the University of Melbourne and the International Institute for Applied Systems Analysis (IIASA). The model configuration used to quantify the projected temperature implications of NDCs and longer-term net-zero targets was also used by our team to assist the IEA to deliver the World Energy Outlook, and other scientific endeavours.

NDCs and LT-LEDS quantifications: The NDCs and LT-LETDS are quantified in terms of their total GHG emissions. While several NDC and LT-LEDS are difficult to quantify, we transparently provide 196 individual country factsheets for all current NDCs and LT-LEDS submitted to the UNFCCC at climate-resource.com/tools/ndcs. This temperature projection is based on the NDCs and LT-LEDS as of 1 December 2023 - considering both conditional and unconditional elements. At Climate Resource, we were one of four global teams (PBL, Climate Action Tracker, and JRC) contributing to the quantitative assessment of NDC and LT-LEDS targets in the IPCC AR6 WG3 report.

Conditional and unconditional targets. The international community is expected to provide support to assist many lower-middle income and low income countries to transition to low-emissions development pathways. Many of those countries' specify both: an unconditional target, which they implement with domestic resources; and, a conditional target with higher emissions reductions, subject to achieving international support. The conditions specified may relate to financial resources, technology transfer, technical cooperation, capacity-building support from other countries, and the availability of market-based mechanisms. High income industrialised (Annex 1) countries only submit unconditional NDCs. Other non-Annex 1 countries that have relatively higher capacity and industrialized economies, such as South Korea, Mexico or China, also submit only unconditional NDCs. We quantify emissions consistent with conditional targets assuming that all conditions are met. We also quantify emissions consistent with unconditional targets separately.

[43] The extended data table 2 is available at https://www.nature.com/articles/s41586-022-04553-z/tables/2

[44] Available at: https://data.climateresource.com.au/ndc/20231211-briefing/20231201c_TP_scenario_summary.csv

[45] The high ambition, conditional pathway (Scenario A in Table 1) : https://live.magicc.org/public/scenarios/c995f17e-ae87-48c6-b3bc-9323d1fb2500 and low ambition, unconditional pathway (Scenario B in Table 1) https://live.magicc.org/public/scenarios/7e8ddf40-9e91-4972-8e8e-ae2510d22645. A comparison of these scenarios is available here: https://live.magicc.org/public/scenarios/compare?uuid=7e8ddf40-9e91-4972-8e8e-ae2510d22645&uuid=c995f17e-ae87-48c6-b3bc-9323d1fb2500

Hot Air: In this analysis, we assume that NDC target levels that are higher than high reference scenarios (i.e. scenarios without additional climate or energy policies to reduce emissions) are not going to be reached, but "overachieved". (Overachievement is the wrong word, as the NDC targets are simply set too high). Specifically, we assume a country-downscaled NGFS 'current policy' scenarios provided by the GCAM integrated assessment model[46]. As a sensitivity test, we also compute GHG emissions and global-mean temperature projections without this cap on hot air. See Table 1 below.

Extension beyond 2030/2050: The peak and end of century temperatures obviously depend a great deal on the assumptions made beyond the horizon of a country's pledge, whether that is 2030 or 2050. With more and more net-zero targets, that influence of the methodological choice is diminishing, though. Here, we use the NGFS GCAM 'current policy' reference scenario for growth rates of sectors not covered by NDCs and constant 2025-2030 emission growth or decline rates for the period 2030 – 2050. In the case of quantifying the NDCs up to 2030 only (without long-term targets), the extrapolation between 2030-2100 is based on continuing growth rates (derived on the growth rate from 2025-2030) out to 2050, and from 2050-2100 using comparable scenarios from the SR1.5 Database (as described in Meinshausen et al., 2022)[47].

[46] available at: https://zenodo.org/records/7085758
[47] available at: https://www.nature.com/articles/s41586-022-04553-z

Table 1 - Detailed results for our climate assessment of current NDC pledges and long-term targets. *The scenarios correspond to the respective scenarios in the Extended Data Table 2 of Meinshausen et al., 2022[48].*

2023

Label	Ambition ambiguity (high or low)	Conditionalty (C = full implementation; U = unconditional only)	Country-level extension 2030-2050	Hot Air (E= excl.; I = Incl.)	Exceedance Probability for temperature level (%)				Peak Warming (C)					Year of Peak Warming					Warming in 2100 (C)				
					1.5C	2.0C	2.5C	3.0C	5%	33%	Median	67%	95%	5%	33%	Median	67%	95%	5%	33%	Median	67%	95%
A	high	C	SSP1BL	exclude	0.85	0.31	0.09	0.01	1.35	1.68	1.83	1.98	2.64	2048	2059	2069	2069	2100	1.22	1.58	1.74	1.93	2.64
B	low	U	SSP1BL	exclude	0.9	0.43	0.13	0.02	1.41	1.76	1.93	2.10	2.82	2049	2070	2082	2093	2100	1.34	1.72	1.9	2.09	2.82
a	high	C	2030	exclude	0.95	0.56	0.2	0.06	1.50	1.90	2.08	2.28	3.07	2070	2094	2094	2100	2100	1.48	1.9	2.08	2.28	3.07
b	high	C	2030	include	0.92	0.5	0.16	0.04	1.45	1.83	2.00	2.19	2.95	2060	2093	2094	2094	2100	1.41	1.81	2	2.19	2.95
c	low	C	2030	exclude	0.97	0.68	0.25	0.1	1.58	2.00	2.20	2.40	3.24	2093	2094	2100	2100	2100	1.56	2	2.19	2.39	3.24
d	low	C	2030	include	0.97	0.68	0.26	0.1	1.59	2.01	2.21	2.41	3.25	2070	2094	2100	2100	2100	1.57	2.01	2.2	2.4	3.25
e	high	U	2030	exclude	0.97	0.67	0.25	0.1	1.58	2.00	2.19	2.39	3.23	2093	2094	2100	2100	2100	1.56	2	2.19	2.39	3.23
f	low	U	2030	exclude	0.99	0.82	0.44	0.16	1.74	2.22	2.43	2.65	3.59	2094	2100	2100	2100	2100	1.73	2.22	2.43	2.65	3.59
g	high	U	2030	include	0.98	0.74	0.33	0.12	1.65	2.09	2.29	2.50	3.39	2093	2100	2100	2100	2100	1.63	2.09	2.29	2.5	3.39
h	low	U	2030	include	1	0.9	0.56	0.23	1.86	2.36	2.59	2.83	3.82	2100	2100	2100	2100	2100	1.86	2.36	2.59	2.83	3.82

[48] Note that extensions beyond the considered target horizon, 2030 or 2050, introduce additional uncertainties, so considering an ensemble of cases or studies is likely more robust than a single scenario. More details on the methodology available at: https://www.nature.com/articles/s41586-022-04553-z/tables/2

7. Further reading and other reports

There is a very useful collection of other reports and analysis on the question of what NDCs and long-term targets mean for future emissions of different countries and global temperatures. We contributed to many of these other analyses in one form or another. Those analyses include, for example, the reports below that often include last year's NDC updates (in addition, there are many scientific literature articles that come with a bit of a delay):

- The UNEP Emission Gap report[s] (Climate Resource was one of four global teams providing NDC quantifications)[49]
- The UNFCCC Synthesis Report[50]
- The IPCC AR6 WG3 report (we were one of four studies taken into account for the IPCC AR6 WG3 assessment, see section 4.2 and Table 4.3 in Chapter 4)[51]
- The Climate Action Tracker analysis as of Dec 2023 (We provide our MAGICC7 model to the CAT team)[52]
- The WRI Climate Watch tools[53], and
- PBL NDC quantifications[54].

About Climate Resource:
Climate Resource was established in mid 2020. We use climate science to create tools that support decision makers to assess and respond to climate risk, and the opportunities in the transition to a net-zero emissions global economy. We're doing all we can to ensure the best science accelerates an effective global response to climate change.
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[49] https://www.unep.org/resources/emissions-gap-report-2023
[50] https://unfccc.int/sites/default/files/resource/cma2023_12.pdf
[51] https://www.ipcc.ch/report/ar6/wg3/
[52] https://climateactiontracker.org/publications/no-change-to-warming-as-fossil-fuel-endgame-brings-focus-onto-false-solutions/
[53] https://www.climatewatchdata.org/ndcs-explore
[54] https://themasites.pbl.nl/o/climate-ndc-policies-tool/