4 The emissions gap

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4.1 Introduction

The emissions gap is defined as the difference between the estimated total global greenhouse gas (GHG) emissions resulting from the full implementation of the nationally determined contributions (NDCs), and the total global GHG emissions from least-cost pathways consistent with the Paris Agreement long-term goal of limiting global average temperature increase to well below 2°C, and pursuing efforts to limit it to 1.5°C relative to pre-industrial levels. Or in other words, the gap between promised and needed emission reductions. The key questions assessed in this chapter are, what is the current best estimate of the emissions gap for 2030 considering the latest NDCs? What levels of global emissions are in line with the climate mitigation goals of the Paris Agreement? Where are we headed under current policies and various mitigation pledge scenarios in terms of global warming over the course of the century?

The assembled scenarios reflect the latest findings from the reports released by Intergovernmental Panel on Climate Change (IPCC) Working Groups I and III under the *Sixth Assessment Report* (AR6) (Canadell *et al.* 2021; IPCC 2021; Byers *et al.* 2022; IPCC 2022b; Lecocq *et al.* 2022; Riahi *et al.* 2022), ensuring consistency with the most recent climate science and mitigation trajectory assumptions. The achievement of net-zero GHG emissions, as aimed for under the Paris Agreement, was considered as part of the scenario classification. Current policies and NDC scenarios are also aligned with the assessment of the IPCC AR6 WGIII Report (Lecocq *et al.* 2022), taking into account the impact of COVID-19 and updated policies on future emission levels. Moving beyond the IPCC assessment, the NDC scenario uses updated emissions projections based on the same studies assessed in the AR6 WGIII Report, but including NDC updates up to a cut-off date of 23 September 2022.[1]

Improving on earlier emissions gap estimates, this chapter uses updated information on land use, land-use change and forestry emissions from national inventory data and the most recent IPCC AR6 values of global warming potential over 100 years (GWP100); it harmonizes the differences between global emissions data and scenarios. Resolving these issues results in changes in the global emissions projections for current policies, NDCs and temperature pathways, compared with previous Emissions Gap Reports, as well as with the estimates included in the United Nations Framework Convention on Climate Change (UNFCCC) Synthesis Report (UNFCCC 2021) and the AR6 WGIII Report (IPCC 2022). The updates mean that the estimates in this chapter cannot be directly compared with previous Emissions Gap Report estimates. However, differences in the estimates are explained in this chapter, and the report's central finding remains: current policies and NDCs are woefully insufficient to meet the temperature goal of the Paris Agreement.

The chapter first introduces the updated scenarios that underlie the quantification of the emissions gap (section 4.2). The emissions gap assessment for 2030 is presented in section 4.3, and the global temperature implications are discussed in section 4.4.

1 The IPCC AR6 assessed studies with cut-off dates varying between May 2021 and October 2021.

4.2 Scenarios considered for the 2030 emissions gap assessment

This section updates the three scenario categories considered for the 2030 emissions gap assessment. These categories comprise reference and current policies scenarios (section 4.2.1), new and updated NDC scenarios (4.2.2), and least-cost mitigation scenarios starting in 2020 consistent with specific temperature targets (4.2.3). All scenarios are summarized in table 4.1.

Table 4.1 Summary of assessed scenarios

Scenario	Number of scenarios in set	Global total emissions in 2030 ($GtCO_2e$)	Estimated temperature outcomes†
Reference and current policies scenarios	Reference or year 2010 policies	2010	This scenario only includes climate polices implemented up to 2010 and assumes no additional measures from 2010 onward.
	Current policies	2021	This scenario covers current policies and projects global GHG implications of climate mitigation policies adopted and implemented as of 2021. These scenarios account for the short-term and midterm socioeconomic impacts of COVID-19[2] (cut-off date: November 2021) and are adjusted for the impact of the Inflation Reduction Act in the United States of America.
NDC scenarios	Unconditional NDCs	2022	This scenario covers all the latest versions of the NDCs that have been indicated to be implemented without any explicit external support (cut-off date: 23 September 2022).
	Conditional NDCs	2022	In addition to the unconditional pledges, this scenario covers the latest versions of NDCs to be implemented conditional upon receiving international support (finance, technology transfer and/or capacity-building) (cut-off date: 23 September 2022).
Mitigation scenarios consistent with keeping warming below specific temperature limits	Below 2°C	N/A	Long-term least-cost pathway starting from 2020 and consistent with holding global warming below 2°C throughout the twenty-first century with at least 66% chance.
	Below 1.8°C	N/A	Long-term least-cost pathway starting from 2020 and consistent with holding global warming below 1.8°C throughout the twenty-first century with at least 66% chance.
	Below 1.5°C	N/A	Long-term least-cost pathway starting from 2020 and consistent with holding global warming below 1.5°C throughout the twenty-first century with limited or no overshoot.[3] This implies global warming in 2100 being held below 1.5°C with at least 66% chance, while throughout the twenty-first century it is kept below 1.5°C with at least 33% chance. In addition, consistent with the Paris Agreement, these scenarios achieve net-zero GHG emissions in the second half of the century.

2 The current policy scenario adjusts original modelling studies to account for different policy cut-off dates, which range from 2017 to 2020, and varying consideration of the impact of the COVID-19 pandemic on socioeconomic drivers.

3 The below 1.5°C definition used in the 2022 Emissions Gap Report is consistent with the C1a category of the IPCC AR6 WGIII Summary for policymakers and selects scenarios based on both their temperature outcome and on whether they reach net-zero GHG emissions over the course of the century in line with the Paris Agreement article 4 (Schleussner *et al.* 2022).

4.2.1 Reference and current policies scenarios

Two scenarios are considered: the reference or year 2010 policies scenario and the updated current policies scenario.

The **year 2010 policies scenario** assumes that no additional climate mitigation policies are implemented after 2010. Global GHG emissions in this scenario are based on the scenarios assessed by the IPCC under AR6 WGIII category C8 (Byers *et al.* 2022; IPCC 2022a; Riahi *et al.* 2022). The estimated global emissions in 2030 under the year 2010 policies scenario is 66 $GtCO_2e$ (range: 64–68).

The **current policies scenario** projects global GHG emissions assuming all currently adopted and implemented policies (defined as legislative decisions, executive orders or equivalent) are realized and that no additional measures are undertaken. Typically, selected policies are based on literature research, input from the Climate Policy Database (NewClimate Institute 2020) and a country expert review of the policies identified, often following a modelling protocol for the implementation of policies in global models from Roelfsema *et al.* (2020; 2022). The data for this scenario are based on the same four modelling studies of the current policies assessment of the IPCC AR6 WGIII Report (Lecocq *et al.* 2022), but using more recent data from the same four modelling studies that provide updated estimates that apply the most recent AR6 GWP100 values and use a policy cut-off date of November 2021 (see table 4.1 and appendix C, available online, for further detail) (Climate Action Tracker 2021; Keramidas *et al.* 2021; Riahi *et al.* 2021; den Elzen *et al.* 2022; Roelfsema *et al.* 2022). The scenario considers the impact of COVID-19 on GHG emissions projections, and the projections are adjusted to include the expected emission reductions from the Inflation Reduction Act in the United States of America (amounting to about 1 $GtCO_2e$). The GHG emissions projections for the current policies scenarios were harmonized with 2015 emissions based on the IPCC AR6 historical emissions database (see box 4.1). The resulting median estimate of global GHG emissions in 2030 under current policies is 58 $GtCO_2e$ (range: 52–60). This is 3 $GtCO_2e$ higher than the estimate of the 2021 United Nations Environment Programme (UNEP) Emissions Gap Report (accounting for the impact of the United States of America). About half of the increase is due to the harmonization, about one quarter to the change in global warming potential (GWP), and the remaining increase is due to the methodological choice of only selecting model studies that explicitly account for the most recent current polices and NDC estimates (table 4.2).

4.2.2 NDC scenarios

The NDC scenarios cover the most recent versions of the NDCs submitted, with a cut-off date of 23 September 2022. The estimates are based on the studies used in the IPCC AR6 WGIII assessment (see table 4.2 of Lecocq *et al.* 2022); however, to reflect NDCs submitted since the IPCC publication, updated estimates have been provided. The data come from four model groups with cut-off dates ranging from November 2021 to February 2022 across studies (Climate Action Tracker 2021; Keramidas *et al.* 2021; den Elzen *et al.* 2022; Meinshausen *et al.* 2022). To include the implications of new or updated NDCs submitted by certain G20 members after these cut-off dates (i.e. Australia, Brazil, India, Indonesia, Republic of Korea and the United Kingdom), NDC emission estimates were recalculated based on the historical emissions data used in respective studies (following the same approach as in chapter 3).

The latest versions of the unconditional NDCs result in an annual emissions reduction of about 0.7 $GtCO_2e$ compared with last year's report (table 4.2, NDC updates column). As with the reference and current policies scenarios, the NDC scenarios were also harmonized with historical 2015 emissions (see box 4.1).

Table 4.2 The impact of the various updates on the GHG emissions projections (median estimates)

Scenario	Emissions Gap Report 2022	Emissions Gap Report 2021	Difference EGR 2022-2021	Factors explaining differences between EGR 2022 and EGR 2021 estimates				
				NDC updates	Methods	AR6 GWP	Harmonization	Scenario literature update
Year 2010 policies	66.4	64.4	+2.0			+0.9	+1.1	
Current policies	58.0	55.0	+3.0		+1.3	+0.8	+1.9	-1.0*
Unconditional NDCs	55.4	52.0	+3.4	-0.7	+0.8	+0.8	+2.5	
Conditional NDCs	52.4	49.7	+2.7	-0.7	+0.5	+0.7	+2.2	
Below 2.0°C	40.7	39.2	+1.5			+0.6		+0.9
Below 1.8°C	34.7	33.2	+1.6			+0.5		+1.1
Below 1.5°C	32.7	24.6	+8.2			+0.4		+7.8

* Impact of Inflation Reduction Act in the United States of America.

The unconditional and conditional NDC scenarios result in projected median global GHG emissions in 2030 of 55 $GtCO_2e$ (range: 52–57) and 52 $GtCO_2e$, (range: 49–54) respectively. These projections are 3.5 $GtCO_2e$ and 3 $GtCO_2e$ higher than the median estimates of the 2021 UNEP Emissions Gap Report, respectively, for reasons similar to those explaining the changes in the current policies scenario (see table 4.2). The harmonization of scenario projections and estimates of historical emissions are also the dominant factor here (see table 4.2), in addition to the impact due to the change in GWP and the change in methodological choice of only selecting model studies that account for the most recent NDCs. Note that this year's update also accounts for the impact of the updated NDCs made between the September cut-off date of the 2021 Emissions Gap Report and November 2021.

Box 4.1 Harmonization of emissions data

Historical emission inventories and emissions projections from global integrated assessment models differ and are associated with uncertainties (see chapter 2, Dhakal *et al.* 2022). To ensure comparability, data sources in this year's report were harmonized through the following three steps:

1. Discrepancies between the emissions of scenarios from the IPCC AR6 WGIII scenario database (Byers *et al.* 2022; Riahi *et al.* 2022) and updated historical global emissions estimates were harmonized as part of the IPCC AR6 scenario pipeline (Kikstra *et al.* 2022).

2. Emissions data from NDC estimates (based on a national inventory approach) and global integrated assessment modelling scenarios (consistent with a bookkeeping approach) were made conceptually more comparable in terms of the land use, land-use change and forestry emissions definition that they use, based on the harmonization presented in Grassi *et al.* (2021) (see chapter 2 and appendix A for further details).

3. The difference between historical emissions assumed in NDC studies and the historical emissions database of the IPCC AR6 was resolved by applying the modelled absolute change between the harmonization year and the 2030 projections of NDC studies to the historical emissions database of the IPCC AR6 for 2015.

These methodological updates improve the comparability of values across chapters, but it is important to note that they limit the comparability of this year's estimate with those of previous editions of the Emissions Gap Report.

4.2.3 Mitigation scenarios keeping warming below specified temperature limits

To assess the emissions and implementation gaps in 2030, current policies and NDC scenarios are compared with least-cost mitigation scenarios that are consistent with keeping warming below specific temperature limits. Least-cost mitigation scenarios are in line with the principle of the UNFCCC that "policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost" (UNFCCC 1992). However, least-cost mitigation scenarios generally do not account for the economic co-benefits and avoided damages of mitigation (see box 4.2). Emission pathways from the literature are categorized according to their projected peak global warming outcomes relative to pre-industrial levels over the course of this century. Three scenarios are defined to reflect the three different levels of warming relevant for the temperature goal of the Paris Agreement: 2°C, 1.8°C and 1.5°C (see tables 4.1 and 4.3).

As outlined in the introduction to this chapter, this year the mitigation scenarios have been updated based on the latest set of scenarios collected as part of the IPCC AR6 WGIII Report (Byers *et al.* 2022; Riahi *et al.* 2022), with temperature projections based on the physical science assessment by Working Group I under the IPCC AR6 (Forster *et al.* 2021).

Table 4.3 Global total GHG emissions in 2030 and global warming characteristics of different scenarios consistent with limiting global warming to specific temperature limits

Scenario	Number of scenarios	Global total GHG emissions ($GtCO_2e$)		Estimated temperature outcome			Closest approximate
		In 2030	In 2050	50% chance	66% chance	90% chance	IPCC AR6 WGIII scenario class
Below 2.0°C (66% chance)*	195	41 (37–46)	20 (16–24)	Peak: 1.7–1.8°C In 2100: 1.4-1.7°C	Peak: 1.8–1.9°C In 2100: 1.6–1.9°C	Peak: 2.2–2.4°C In 2100: 2.0–2.4°C	C3a
Below 1.8°C (66% chance)*	139	35 (28–40)	12 (8–16)	Peak: 1.5–1.7°C In 2100: 1.3-1.6°C	Peak: 1.6–1.8°C In 2100: 1.4–1.7°C	Peak: 1.9–2.2°C In 2100: 1.8–2.2°C	N/A
Below 1.5°C (66% in 2100 with no or limited overshoot)*	50	33 (26–34)	8 (5–13)	Peak: 1.5–1.6°C In 2100: 1.1–1.3°C	Peak: 1.6–1.7°C In 2100: 1.2–1.5°C	Peak: 1.9–2.1°C In 2100: 1.6–1.9°C	C1a

* Values represent the median and tenth to ninetieth percentile range across scenarios. Percentage chance refers to peak warming at any time during the twenty-first century for the below 1.8°C and below 2.0°C scenarios. When achieving net-negative CO_2 emissions in the second half of the century, global warming can be further reduced from these peak warming characteristics, as illustrated by the "Estimated temperature outcome" columns. For the below 1.5°C scenario, the chance applies to the global warming in the year 2100, while the "no or limited overshoot" characteristic is captured by ensuring projections do not exceed 1.5°C with more than 67 per cent chance over the course of the twenty-first century or, in other words, that the lowest chance of warming being limited to 1.5°C throughout the entire twenty-first century is never less than 33 per cent. This definition is identical to the C1 category definition used by the IPCC AR6 WG III report. Compared to IPCC (2022), the Emissions Gap Report analysis also selects scenarios based on whether or not they assume immediate action.

Notes: GHG emissions in this table have been aggregated with GWP100 values of IPCC AR6.

Source: Based on underlying data from Byers *et al.* (2022) and Riahi *et al.* (2022)

The 2030 emission benchmark values of the least-cost mitigation pathways in this year's report are higher than those in previous reports, especially for the below 1.5°C scenario. There are two main reasons for this (table 4.2). The most important is the update of the scenario literature evidence base collected in support of the IPCC AR6 (Byers *et al.* 2022; Riahi *et al.* 2022). The rate of emissions decline after 2020 in the below 1.5°C scenario[4] is similar to that of the IPCC Special Report on global warming of 1.5°C and the IPCC AR6. However, the AR6 scenarios show higher GHG emissions in 2030 because the emission reductions generally start from higher levels in 2020, as reflected in the most recent historical emissions inventories (IPCC 2022a; IPCC 2022b). More scenarios in the IPCC AR6 scenario database also end up closer to the temperature limit in the below 1.5°C scenario category (see table 4.3), which again results in higher 2030 emission values.[5] A second, more minor contributing factor, which affects all scenario categories, is the update to the most recent IPCC AR6 values of GWP100.

4 These scenarios are all within the IPCC AR6 WGIII category C1.

5 A detailed discussion of this change between the IPCC Special Report on global warming of 1.5°C and the AR6 WGIII Report is provided in appendix III to the IPCC AR6 WGIII Report (IPCC 2022a), section 3.2.1.

Box 4.2 Putting cost estimates from least-cost emissions scenarios in context

Least-cost scenarios are constructed to achieve global emission reductions at the lowest cost possible. However, estimates of mitigation costs vary extensively and depend critically on the reference and mitigation scenario assumptions and data parameterization chosen (Köberle *et al.* 2021; Riahi *et al.* 2022). If a reference scenario in which global and local economies are at their efficiency frontier is assumed, climate policies will inevitably entail macroeconomic costs. However, the literature, including the latest IPCC assessment, illustrates that this is a stylized and unrealistic assumption (Riahi *et al.* 2022). An economy at its efficiency frontier implies no fossil fuel subsidies, no taxation that distorts the allocation of labour, no "misallocation or under-utilization of production factors such as involuntary unemployment", and no "imperfect information or non-rational behaviours" (Riahi *et al.* 2022). Each of these economic imperfections are common across real-world economies at all levels of development. However, the models that produce least-cost pathways rarely represent all these aspects and hence disregard them in their model estimates of mitigation costs. This results in mitigation cost estimates that are biased high (Köberle *et al.* 2021; Riahi *et al.* 2022). Studies that model a reference economy below the efficiency frontier find that a low-carbon transformation can result in economic stimulus and increase economic growth, conditional on green investments not replacing investment in other parts of the economy (Pollitt and Mercure 2018; Mercure *et al.* 2019; Riahi *et al.* 2022). Because of regional differences in governance, development and societal and technological context, mitigation cost estimates differ between countries. For example, under the idealized assumption that emission reductions are achieved through a globally uniform carbon price, countries with carbon-intensive economies or fossil fuel exporting countries would have relatively higher macroeconomic costs as their economies require a deeper transformation (Stern, Pezzey and Lambie 2012; Tavoni *et al.* 2015; Böhringer *et al.* 2021). For a detailed discussion see Riahi *et al.* (2022).

In addition, mitigation cost estimates of least-cost pathways disregard the economic benefits that accrue through avoided damages and societal co-benefits of a low-carbon transition, such as improved public health because of improved air quality (Köberle *et al.* 2021; Riahi *et al.* 2022). Even when considering least-cost mitigation scenarios where costs are biased high, these benefits likely outstrip the modelled costs (see figure 4.1) (Riahi *et al.* 2022). For example, one study found that health co-benefits outweigh the policy cost of achieving fair national contributions to limit warming to 1.5°C in China and India, with the modelled costs compensated by health co-benefits (Markandya *et al.* 2018).

In conclusion, typically an ideal, perfectly working economy is assumed when mitigation costs are quantified, while the economic co-benefits and avoided damages are unaccounted for. As a result, modelled mitigation cost estimates typically only provide limited real-world insights about the net burden to economies or society. In all cases, these modelled costs occur in a world of continued economic development and growth.

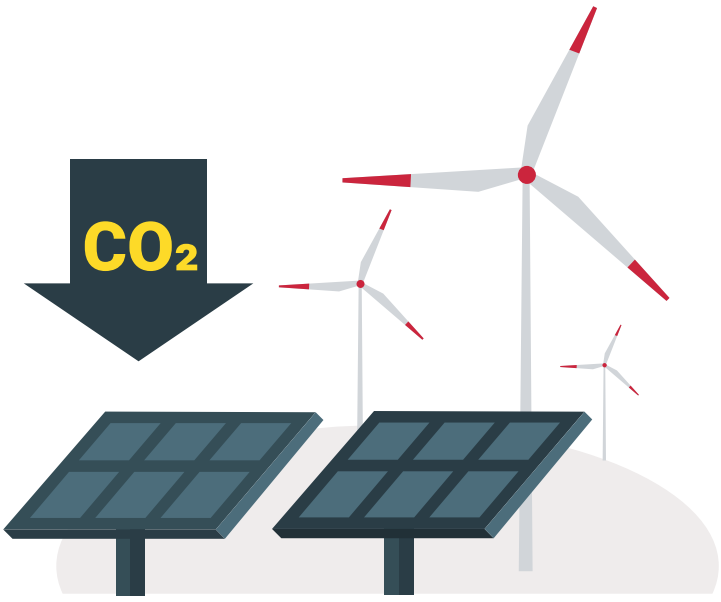
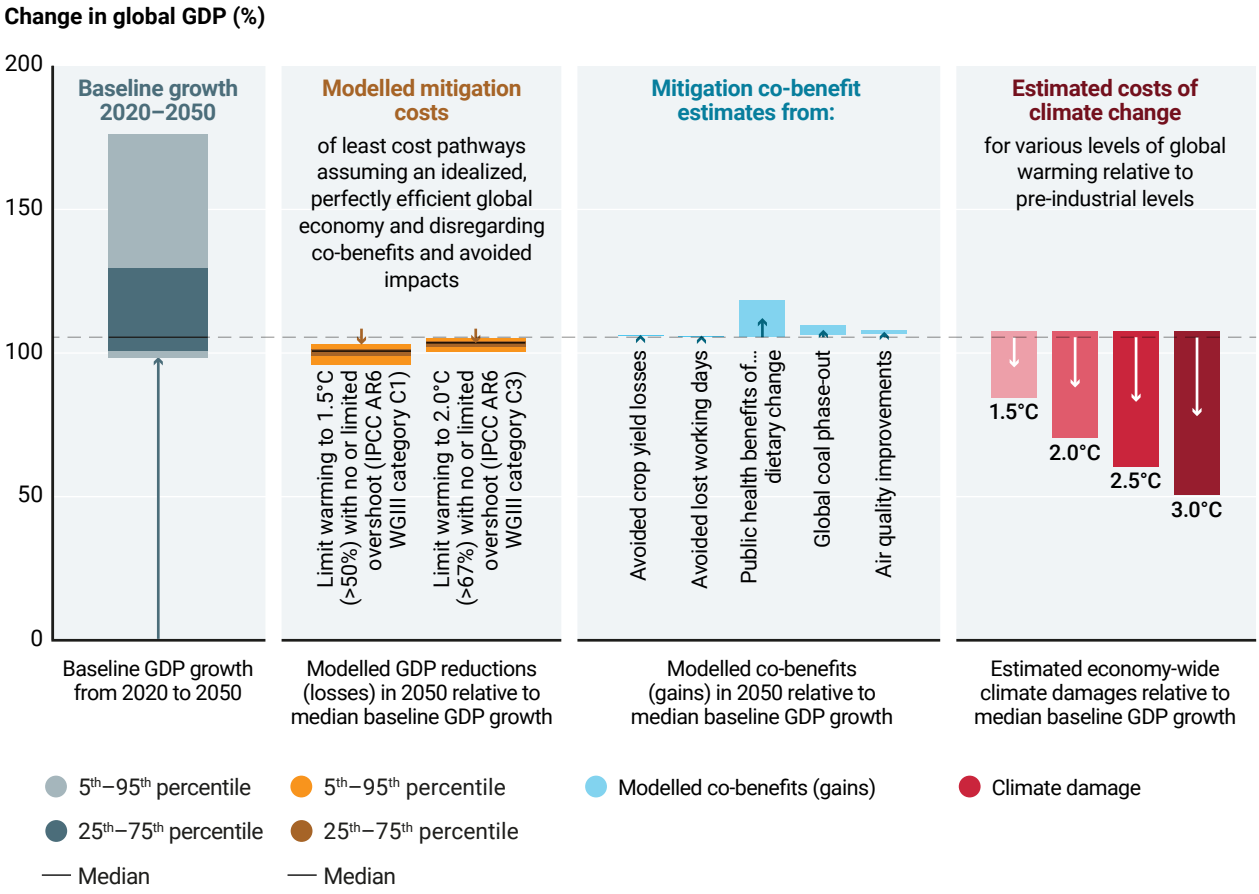


Figure 4.1 Estimated implications for global GDP of mitigation measures, co-benefits and climate damages



Sources: Global baseline GDP growth projections and modelled mitigation costs are from the IPCC AR6 WGIII scenario database (Byers *et al.* 2022; Riahi *et al.* 2022). Modelled GDP co-benefits: crop yields based on Vandyck *et al.* (2018); avoided lost labour days derived from Vandyck *et al.* (2018); public health benefits of a healthier diet from Springmann *et al.* (2016); public health benefits of a global coal exit based on Rauner *et al.* (2020); and an additional estimate of co-benefits from air-quality improvements from stringent mitigation following from Markandya *et al.* (2018). Estimated GDP reductions from economy-wide climate damages are based on the IPCC AR6 WGII Cross-Working Group Box on Economics (O'Neill *et al.* 2022). The latter are quantified for when a specific level of global warming is reached for the first time, irrespective of when exactly this takes place. Note that under current policies, global warming by 2050 can range up to about 2.0–2.5°C. Global warming of 3.0°C would only be achieved later in the century.

Notes: Dark lines in global baseline GDP growth projections and modelled mitigation costs are median estimates, with dark and light ranges representing 25–75 per cent and 5–95 per cent confidence intervals respectively. Mitigation co-benefit estimates cannot be aggregated across sources.

4.3 The emissions gap

The emissions gap for 2030 is defined as the difference between estimated global GHG emissions resulting from full implementation of NDCs, and global total GHG emissions under least-cost scenarios that keep global warming to below 2°C, 1.8°C or 1.5°C with varying levels of chance (see table 4.4). This section updates the gap based on the scenarios described in section 4.2.

Figure 4.2 shows the emissions gap for 2030, with table 4.4 indicating the details. While the latest NDCs narrow the gap slightly compared with previous NDCs, they are highly insufficient to bridge the gap. Altogether, they reduce expected emissions in 2030 under current policies by only 5 per cent. Meeting all conditions and implementing the conditional NDCs would take this reduction to 10 per cent, whereas 30 or 45 per cent is needed for 2.0°C or 1.5°C, respectively.

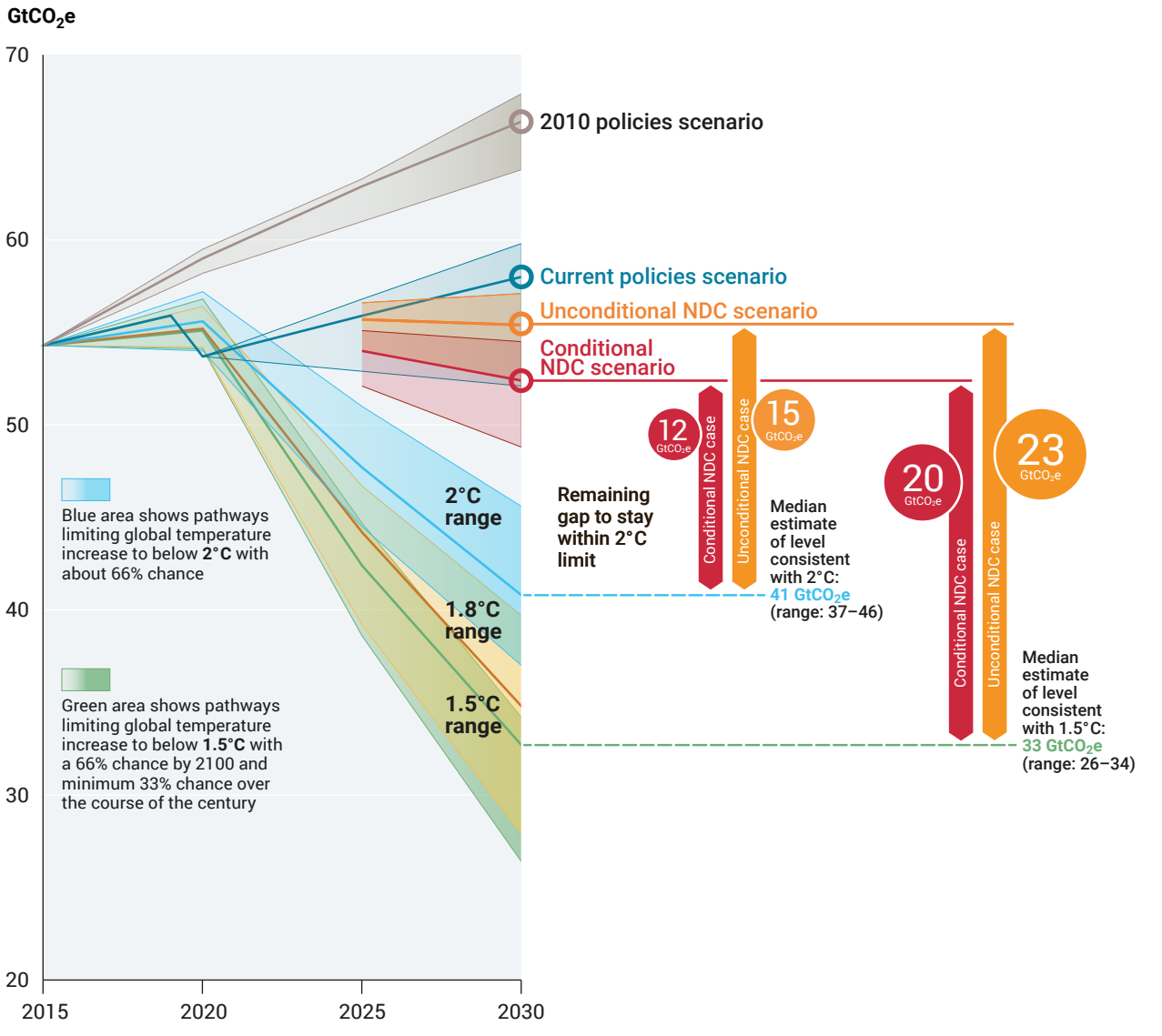
Full implementation of unconditional NDCs is estimated to result in a gap to the 1.5°C scenario of 23 $GtCO_2e$ (range: 20–24). This is about 5 $GtCO_2e$ smaller than estimated in the 2021 report (UNEP 2021) – a difference that is almost entirely due to updates to the 1.5°C scenarios (see table 4.2). As outlined in section 4.2.3, these show higher emissions in 2030 because they start their reductions from higher 2020 emission levels, reflecting a global delay in ambitious climate action. This delay is not without consequences: on average the below 1.5°C scenarios now have a lower chance of effectively keeping warming to 1.5°C . If the conditional NDCs are also fully implemented, the emissions gap to the 1.5°C scenario is reduced by about 3 $GtCO_2e$.

The emissions gap between unconditional NDCs and below 2°C pathways is about 15 $GtCO_2e$ (range: 12–16 $GtCO_2e$), which is about 2 $GtCO_2e$ larger than last year. The main reason for this increase in the assessed gap for 2°C is that this year's report corrects for discrepancies in historical emissions through harmonization (see table 4.2 and box 4.1). Again, the additional full implementation of the conditional NDCs, lowers the emissions gap to the 2°C scenario by about 3 $GtCO_2e$.

In conclusion, the central message remains: NDCs are highly insufficient to put the world on a path to meeting the temperature goal of the Paris Agreement.

Furthermore, countries are not yet on track to achieve these globally insufficient NDCs. The implementation gap, which is the difference between emissions expected under the current policies scenario and those needed to achieve the NDCs, is estimated to be about 3 $GtCO_2e$ and 6 $GtCO_2e$ for the unconditional and conditional NDC scenarios respectively (table 4.4). These gap estimates are 1 $GtCO_2e$ and 3 $GtCO_2e$ larger than last year, mainly because NDCs have been updated while policies have not yet followed suit.

Figure 4.2 GHG emissions under different scenarios and the emissions gap in 2030 (median estimate and tenth to ninetieth percentile range)



With eight years left to bridge the emissions gap, the urgency of rapid emission reductions is clear. The urgency is equally evident when considering the remaining carbon budget. The carbon budget refers to the maximum amount of cumulative net global anthropogenic CO_2 emissions that would result in limiting global warming to a given level with a given chance, taking into account the effect of other anthropogenic climate forcers. The IPCC estimates that the remaining carbon budget from the beginning of 2020 for limiting warming to a maximum of 1.5°C is approximately 400 $GtCO_2$ and 1,150 $GtCO_2$ for 2°C (both with a 67 per cent chance) (IPCC 2021). When comparing with the current

levels of annual global emissions provided in chapter 2, it is evident that the remaining carbon budget for 1.5°C will be exhausted around the end of this decade, unless significant emission reductions are rapidly achieved. In this context, there is growing attention to the potential contributions from reducing emissions from short-lived climate pollutants, particularly methane emissions (see box 4.3).

Table 4.4 Global total GHG emissions in 2030 and the estimated emissions gap under different scenarios

Scenario	GHG emissions in 2030 ($GtCO_2e$)	Estimated emissions gap in 2030 ($GtCO_2e$)		
	Median and range	Below 2.0°C	Below 1.8°C	Below 1.5°C
Year 2010 policies	66 (64–68)	--	--	--
Current policies	58 (52–60)	17 (11–19)	23 (17–25)	25 (19–27)
Unconditional NDCs	55 (52–57)	15 (12–16)	21 (17–22)	23 (20–24)
Conditional NDCs	52 (49–54)	12 (8–14)	18 (14–20)	20 (16–22)

Notes: The gap numbers and ranges are calculated based on the original numbers (without rounding), and these may differ from the rounded numbers in the table. Numbers are rounded to full $GtCO_2e$. GHG emissions have been aggregated with the IPCC AR6 values of GWP100.

Box 4.3 The role of rapid methane emission reductions

In conjunction with CO_2 emission reductions, rapid reductions in emissions from methane and other short-lived climate pollutants are critical to lower peak warming, reduce the likelihood of overshoot and decrease the reliance on CO_2 removal methods to limit warming later in this century (IPCC 2021; IPCC 2022). Global average methane concentrations in the atmosphere have increased by 162 per cent compared with pre-industrial levels (WMO 2021). This increase is largely driven by anthropogenic sources, mainly enteric fermentation of livestock and manure, rice cultivation, waste, and fossil fuel exploration (Jackson *et al.* 2020). Methane has a significantly higher global warming potential than CO_2 (80 and 83 times higher over 20 years for biogenic and fossil methane, respectively), but a much shorter atmospheric lifetime (about 12 years) (Forster *et al.* 2021). Reducing methane emissions therefore affects warming rates in the near term, resulting in benefits for ecosystems and people, and enabling humans to adapt to climate change (UNEP 2021).

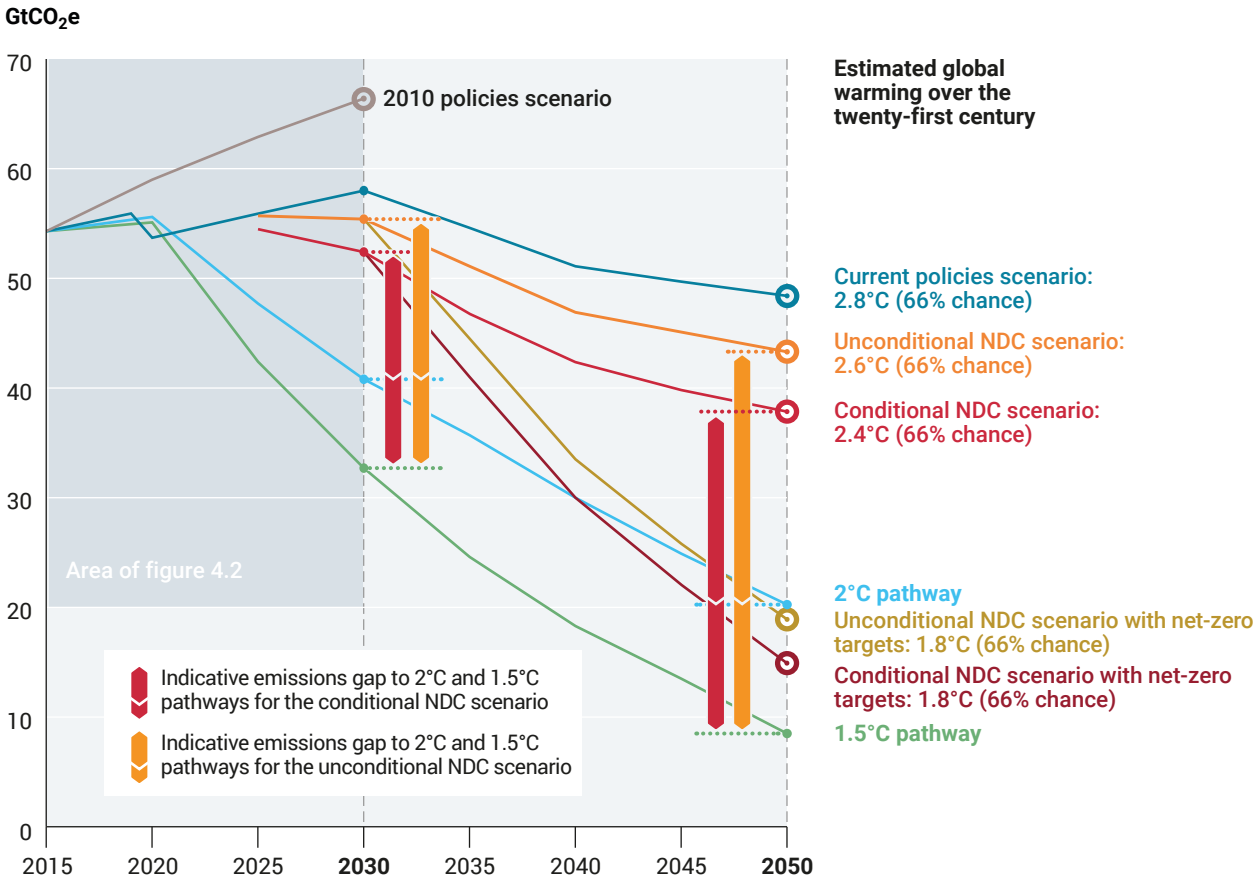
Estimates of the remaining global carbon budget for 1.5°C assume that methane is strongly reduced by at least 30 per cent, 40 per cent and 50 per cent relative to 2020 levels in 2030, 2040 and 2050 respectively (IPCC 2018). Every ca 100 Mt shortfall in methane reductions compared with these benchmarks diminishes the already very small cumulative remaining carbon budget by around 450 $GtCO_2$ (UNEP 2021). Reducing emissions from methane is therefore an essential part of Paris-compatible mitigation strategies.

The 2021 Emissions Gap Report (UNEP 2021) found that global anthropogenic methane emissions can be reduced by around 30 per cent by 2030 through implementation of readily available methane-targeted measures. Implementation of both readily available mitigation measures and broader structural and behavioural measures could reduce methane emissions by nearly 50 per cent by 2030 (UNEP 2021). The largest methane emission reduction potential is available in the fossil fuel sector, followed by the waste sector and the agriculture sector. Roughly one third of all technical mitigation options pay for themselves, with the largest fraction in the oil and gas subsector (UNEP and Climate and Clean Air Coalition 2021).

To realize this opportunity, a Global Methane Pledge was announced at United Nations Climate Change Conference of the Parties (COP) 26, with the aim to reduce global anthropogenic methane emissions by at least 30 per cent by 2030 from 2020 levels. So far, 122 countries have joined the pledge, covering half of global methane emissions and nearly two thirds of the global economy. Large methane emitters such as Australia, China, India, Iran, and the Russian Federation have yet to join the pledge, and efforts to track its implementation are still in the process of being established.

Looking beyond 2030, figure 4.3 projects global GHG emissions out to 2050 under different scenarios and indicates the associated global warming implications over this century (see section 4.3). The figure illustrates the substantial increase in the emissions gap for 2050 if climate efforts implied by current policies and NDC scenarios are continued without further strengthening. Implementation of net-zero targets by around mid-century would significantly reduce these gaps, but even then, gaps with the 1.5°C scenarios would remain.

Figure 4.3 Projections of GHG emissions under different scenarios to 2050 and indications of emissions gap and global warming implications over this century (medians only)



4.4 Temperature implications of the emissions gap

Neither current policies nor NDCs put emissions on track to limit global warming to the temperature goal of the Paris Agreement. The extent of the shortfall in ambition and implementation can also be expressed in terms of the estimated resulting global warming. The same method is applied as in last year's report (see box 4.1 in UNEP 2021) to project the emissions implications of current policies and NDCs from 2030 out to 2100. The global warming implications of these emissions are subsequently assessed with a climate model that captures the latest climate science assessment and uncertainties of the IPCC AR6 (Smith *et al.* 2018; Forster *et al.* 2021). This approach allows accounting for the uncertainties in current policies and NDCs, the degree to which climate action continues beyond 2030, and the uncertainties of how the climate responds to these emissions.

As table 4.5 and figure 4.3 show, a continuation of the level of climate change mitigation efforts implied by current unconditional NDCs is estimated to limit warming over the twenty-first century to about 2.6°C (range: 1.9–3.1°C) with a 66 per cent chance, and warming is expected to increase further after 2100 as CO_2 emissions are not yet projected to reach net-zero levels. Continuing the efforts of conditional NDCs lowers these projections by around 0.2°C to 2.4°C (range: 1.8–3.0°C) for a 66 per cent chance. Because current policies are insufficient to meet even the unconditional NDCs, a continuation of current policies would result in about 0.2°C higher estimates of 2.8°C (range: 1.9–3.3°C) for a 66 per cent chance.

Table 4.5 Estimated global warming implications over the course of the twenty-first century under different scenarios and likelihoods

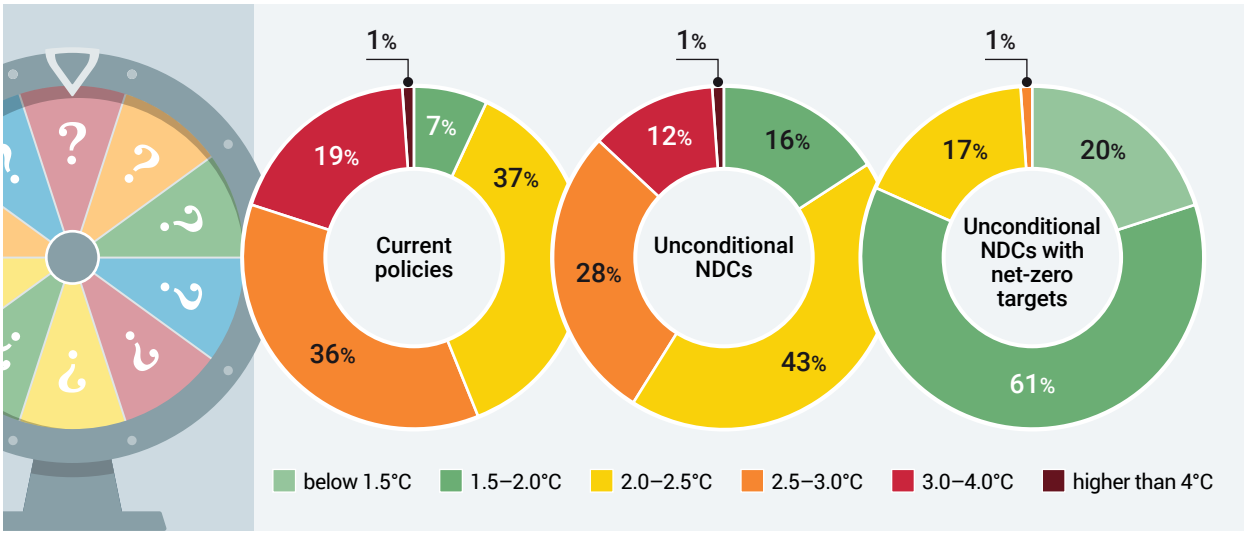
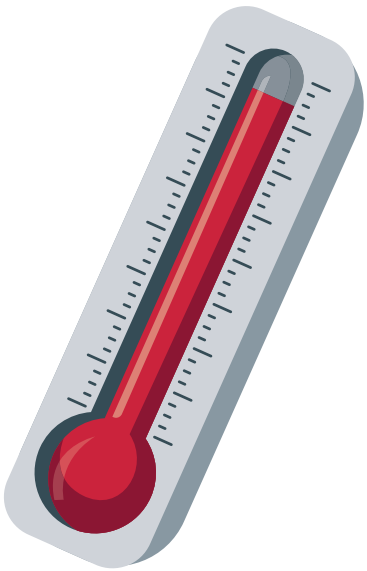
Scenario	Estimated global warming over the twenty-first century with various chances (median and range)		
	66%	50%	90%
Current policies	2.8°C (range: 1.9–3.3°C)	2.6°C (range: 1.7–3.0°C)	3.3°C (range: 2.3–3.9°C)
Unconditional NDCs	2.6°C (range: 1.9–3.1°C)	2.4°C (range: 1.7–2.9°C)	3.1°C (range: 2.3–3.7°C)
Conditional NDCs	2.4°C (range: 1.8–3.0°C)	2.2°C (range: 1.7–2.7°C)	2.8 (range: 2.2–3.5°C)
Unconditional NDCs and long-term net-zero targets	1.8°C (range: 1.8–2.1°C)	1.7°C (range: 1.7–1.9°C)	2.1 (range: 2.0–2.5°C)
Conditional NDCs and long-term net-zero targets	1.8°C (range: 1.7–1.9°C)	1.7°C (range: 1.6–1.8°C)	2.0°C (range: 2.0–2.3°C)

Net-zero targets provide further information about how emissions might evolve after 2030, assuming these targets are achieved. This year's report considers net-zero targets and announcements of the G20 members and nine other countries with at least 100 $MtCO_2e$/year emissions in the year 2018 (see appendix C, table C.3).[6] This is an expansion of the analysis compared with last year, where only targets of G20 members were considered. Achieving net-zero targets in addition to unconditional NDCs results in projected global warming being held to 1.8°C (range: 1.8–2.1°C) with a 66 per cent chance. Assuming that conditional NDCs and pledges are achieved and followed by net-zero targets, global warming is similarly projected to be kept to 1.8°C (range: 1.7–1.9°C) with a 66 per cent chance. However, in most cases neither current policies nor NDCs currently trace a credible path from 2030 towards the achievement of national net-zero targets (see chapter 3).

These temperature projections are slightly lower than those reported in the 2021 Emissions Gap Report, because the latest NDCs, if fully implemented, lower 2030 emissions estimates by about 0.7 $GtCO_2e$ (see table 4.3) and because the inclusion of more countries in the net-zero analysis further lowers emissions projections over the course of the century. The effect of the methodological updates for the gap estimations is much lower, as similar methodological steps were already used in the temperature projections in earlier reports.

As illustrated above, global warming levels only get close to the Paris Agreement temperature goal when full implementation of the highly uncertain net-zero targets is assumed in addition to the NDC scenarios. In addition, there is still significant uncertainty about how much warming we will experience over the course of this century. Figure 4.4 shows the range of global warming outcomes under three scenarios (current policies, unconditional NDCs and unconditional NDCs combined with net-zero targets announced by countries). The figure illustrates that the risk of levels of warming clearly beyond 2°C remains, even under the optimistic assumption of current climate promises expressed in NDCs and net-zero targets. Current policy projections globally lead to about a 20 per cent chance of global warming exceeding 3°C. If measures are put in place that ensure current NDC and net-zero targets will be achieved, the risk of exceeding 3°C is strongly reduced. Taking more ambitious climate actions by 2030 is urgently needed and is of utmost importance for getting the world on track to meeting the Paris Agreement.

6 This estimate assumes countries' emissions remain constant once their net-zero target is achieved.

Figure 4.4 Range of global warming projections for three key scenarios

Range of global warming outcomes projected if current policies (left), unconditional NDCs (middle), and unconditional NDCs combined with net-zero targets announced by countries (right) are achieved.