Frequently Asked Questions (FAQs)

FAQ 3.1 | Is it possible to stabilise warming without net negative CO_2 and GHG emissions?

Yes. Achieving net zero CO_2 emissions and sustaining them into the future is sufficient to stabilise the CO_2-induced warming signal which scales with the cumulative net amount of CO_2 emissions. At the same time, the warming signal of non-CO_2 GHGs can be stabilised or reduced by declining emissions that lead to stable or slightly declining concentrations in the atmosphere. For short-lived GHGs with atmospheric lifetimes of less than 20 years, this is achieved when residual emissions are reduced to levels that are lower than the natural removal of these gases in the atmosphere. Taken together, mitigation pathways that bring CO_2 emissions to net zero and sustain it, while strongly reducing non-CO_2 GHGs to levels that stabilise or decline their aggregate warming contribution, will stabilise warming without using net negative CO_2 emissions and with positive overall GHG emissions when aggregated using GWP-100. A considerable fraction of pathways that limit warming to 1.5°C (>50%) with no or limited overshoot and limit warming to 2°C (>67%), respectively, do not or only marginally (<10 $GtCO_2$ cumulative until 2100) deploy net negative CO_2 emissions (26% and 46%, respectively) and do not reach net zero GHG emissions by the end of the century (48% and 70%, respectively). This is no longer the case in pathways that return warming to 1.5°C (>50%) after a high overshoot (typically >0.1°C). All of these pathways deploy net negative emissions on the order of 360 (60–680) $GtCO_2$ (median and 5–95th percentile) and 87% achieve net negative GHGs emissions in AR6 GWP-100 before the end of the century. Hence, global net negative CO_2 emissions, and net zero or net negative GHG emissions, are only needed to decline, not to stabilise global warming. The deployment of carbon dioxide removal (CDR) is distinct from the deployment of net negative CO_2 emissions, because it is also used to neutralise residual CO_2 emissions to achieve and sustain net zero CO_2 emissions. CDR deployment can be considerable in pathways without net negative emissions and all pathways limiting warming to 1.5°C use it to some extent.

FAQ 3.2 | How can net zero emissions be achieved and what are the implications of net zero emissions for the climate?

Halting global warming in the long term requires, at a minimum, that no additional CO_2 emissions from human activities are added to the atmosphere (i.e., CO_2 emissions must reach 'net' zero). Given that CO_2 emissions constitute the dominant human influence on global climate, global net zero CO_2 emissions are a prerequisite for stabilising warming at any level. However, CO_2 is not the only greenhouse gas that contributes to global warming and reducing emissions of other greenhouse gases (GHGs) alongside CO_2 towards net zero emissions of all GHGs would lower the level at which global temperature would peak. The temperature implications of net zero GHG emissions depend on the bundle of gases that is being considered, and the emissions metric used to calculate aggregated GHG emissions and removals. If reached and sustained, global net zero GHG emissions using the 100-year Global Warming Potential (GWP-100) will lead to gradually declining global temperature.

Not all emissions can be avoided. Achieving net zero CO_2 emissions globally therefore requires deep emissions cuts across all sectors and regions, along with active removal of CO_2 from the atmosphere to balance remaining emissions that may be too difficult, too costly, or impossible to abate at that time. Achieving global net zero GHG emissions would require, in addition, deep reductions of non-CO_2 emissions and additional CO_2 removals to balance remaining non-CO_2 emissions.

Not all regions and sectors must reach net zero CO_2 or GHG emissions individually to achieve global net zero CO_2 or GHG emissions, respectively; instead, positive emissions in one sector or region can be compensated by net negative emissions from another sector or region. The time each sector or region reaches net zero CO_2 or GHG emissions depends on the mitigation options available, the cost of those options, and the policies implemented (including any consideration of equity or fairness). Most modelled pathways that *likely* limit warming to 2°C (>67%) above pre-industrial levels and below use land-based CO_2 removal such as afforestation/reforestation and BECCS to achieve net zero CO_2 and net zero GHG emissions even while some CO_2 and non-CO_2 emissions continue to occur. Pathways with more demand-side interventions that limit the amount of energy we use, or where the diet that we consume is changed, can achieve net zero CO_2, or net zero GHG emissions with less carbon dioxide removal (CDR). All available studies require at least some kind of carbon dioxide removal to reach net zero; that is, there are no studies where absolute zero GHG or even CO_2 emissions are reached by deep emissions reductions alone.

Total GHG emissions are greater than emissions of CO_2 only; reaching net zero CO_2 emissions therefore occurs earlier, by up to several decades, than net zero GHG emissions in all modelled pathways. In most modelled pathways that *likely* limit warming to 2°C (>67%) above pre-industrial levels and below in the most cost-effective way, the agriculture, forestry and other land-use (AFOLU) and energy supply sectors reach net zero CO_2 emissions several decades earlier than other sectors; however, many pathways show much reduced, but still positive, net GHG emissions in the AFOLU sector in 2100.

FAQ 3.3 | How plausible are high emissions scenarios, and how do they inform policy?

IAMs are used to develop a wide range of scenarios describing future trajectories for greenhouse gas emissions based on a wide set of assumptions regarding socio-economic development, technological changes, political development and climate policy. Typically, the IAM-based scenarios can be divided into (i) reference scenarios (describing possible trajectories in the absence of new stringent climate policies) and (ii) mitigation scenarios (describing the impact of various climate policy assumptions). Reference scenarios typically result in high emissions and, subsequently, high levels of climate change (in the order of 2.5°C–4°C during the 21st century). The purpose of such reference scenarios is to explore the consequences of climate change and act as a reference for mitigation scenarios. The possible emission levels for reference scenarios diverge from stabilising and even slowly declining emissions (e.g., for current policy scenarios or SSP1) to very high emission levels (e.g., SSP5 and RCP8.5). The latter leads to nearly 5°C of warming by the end of the century for medium climate sensitivity. Hausfather and Peters (2020) pointed out that since 2011, the rapid development of renewable energy technologies and emerging climate policy have made it considerably less likely that emissions could end up as high as RCP8.5. This means that reaching emissions levels as high as RCP8.5 has become less likely. Still, high emissions cannot be ruled out for many reasons, including political factors and, for instance, higher than anticipated population and economic growth. Climate projections of RCP8.5 can also result from strong feedbacks of climate change on (natural) emission sources and high climate sensitivity (AR6 WGI Chapter 7). Therefore, their median climate impacts might also materialise while following a lower emission path (e.g., Hausfather and Betts 2020). All in all, this means that high-end scenarios have become considerably less likely since AR5 but cannot be ruled out. High-end scenarios (like RCP8.5) can be very useful to explore high-end risks of climate change but are not typical 'business-as-usual' projections and should therefore not be presented as such.