SYNTHESIS REPORT OF THE IPCC SIXTH ASSESSMENT REPORT (AR6)

Longer Report

Core Writing Team: Hoesung Lee (Chair), Katherine Calvin (USA), Dipak Dasgupta (India/USA), Gerhard Krinner (France/Germany), Aditi Mukherji (India), Peter Thorne (Ireland/United Kingdom), Christopher Trisos (South Africa), José Romero (Switzerland), Paulina Aldunce (Chile), Ko Barrett (USA), Gabriel Blanco (Argentina), William W. L. Cheung (Canada), Sarah L. Connors (France/United Kingdom), Fatima Denton (The Gambia), Aïda Diongue-Niang (Senegal), David Dodman (Jamaica/United Kingdom/Netherlands), Matthias Garschagen (Germany), Oliver Geden (Germany), Bronwyn Hayward (New Zealand), Christopher Jones (United Kingdom), Frank Jotzo (Australia), Thelma Krug (Brazil), Rodel Lasco (Philippines), June-Yi Lee (Republic of Korea), Valérie Masson-Delmotte (France), Malte Meinshausen (Australia/Germany), Katja Mintenbeck (Germany), Abdalah Mokssit (Morocco), Friederike E. L. Otto (United Kingdom/Germany), Minal Pathak (India), Anna Pirani (Italy), Elvira Poloczanska (UK/Australia), Hans-Otto Pörtner (Germany), Aromar Revi (India), Debra C. Roberts (South Africa), Joyashree Roy (India/Thailand), Alex C. Ruane (USA), Jim Skea (United Kingdom), Priyadarshi R. Shukla (India), Raphael Slade (United Kingdom), Aimée Slangen (The Netherlands), Youba Sokona (Mali), Anna A. Sörensson (Argentina), Melinda Tignor (USA/Germany), Detlef van Vuuren (The Netherlands), Yi-Ming Wei (China), Harald Winkler (South Africa), Panmao Zhai (China), Zinta Zommers (Latvia)

Extended Writing Team: Jean-Charles Hourcade (France), Francis X. Johnson (Thailand/Sweden), Shonali Pachauri (Austria/India), Nicholas P. Simpson (South Africa/Zimbabwe), Chandni Singh (India), Adelle Thomas (Bahamas), Edmond Totin (Benin)

Contributing Authors: Andrés Alegría (Germany/Honduras), Kyle Armour (USA), Birgit Bednar-Friedl (Austria), Kornelis Blok (The Netherlands) Guéladio Cissé (Switzerland/Mauritania/France), Frank Dentener (EU/Netherlands), Siri Eriksen (Norway), Erich Fischer (Switzerland), Gregory Garner (USA), Céline Guivarch (France), Marjolijn Haasnoot (The Netherlands), Gerrit Hansen (Germany), Matthias Hauser (Switzerland), Ed Hawkins (UK), Tim Hermans (The Netherlands), Robert Kopp (USA), Noëmie Leprince-Ringuet (France), Debora Ley (Mexico/Guatemala), Jared Lewis (Australia/New Zealand), Chloé Ludden (Germany/France), Zebedee Nicholls (Australia), Leila Niamir (Iran/The Netherlands/Austria), Shreya Some (India/Thailand), Sophie Szopa (France), Blair Trewin (Australia), Kaj-Ivar van der Wijst (The Netherlands), Gundula Winter (The Netherlands/Germany), Maximilian Witting (Germany)

Review Editors: Paola Arias (Colombia), Mercedes Bustamante (Brazil), Ismail Elgizouli (Sudan), Gregory Flato (Canada), Mark Howden (Australia), Carlos Méndez (Venezuela), Joy Pereira (Malaysia), Ramón Pichs-Madruga (Cuba), Steven K Rose (USA), Yamina Saheb (Algeria/France), Roberto Sánchez (Mexico), Diana Ürge-Vorsatz (Hungary), Cunde Xiao (China), Noureddine Yassaa (Algeria)

Scientific Steering Committee: Hoesung Lee (Chair, IPCC), Amjad Abdulla (Maldives), Edvin Aldrian (Indonesia), Ko Barrett (United States of America), Eduardo Calvo (Peru), Carlo Carraro (Italy), Fatima Driouech (Morocco), Andreas Fischlin (Switzerland), Jan Fuglestvedt (Norway), Diriba Korecha Dadi (Ethiopia), Thelma Krug (Brazil), Nagmeldin G.E. Mahmoud (Sudan), Valérie Masson-Delmotte (France), Carlos Méndez (Venezuela), Joy Jacqueline Pereira (Malaysia), Ramón Pichs-Madruga (Cuba), Hans-Otto Pörtner (Germany), Andy Reisinger (New Zealand), Debra Roberts (South Africa), Sergey Semenov (Russian Federation), Priyadarshi Shukla (India), Jim Skea (United Kingdom), Youba Sokona (Mali), Kiyoto Tanabe (Japan), Muhammad IrfanTariq (Pakistan), Diana Ürge-Vorsatz (Hungary), Carolina Vera (Argentina), Pius Yanda (United Republic of Tanzania), Noureddine Yassaa (Algeria), Taha M. Zatari (Saudi Arabia), Panmao Zhai (China)

Visual Conception and Information Design: Arlene Birt (USA), Meeyoung Ha (Republic of Korea)

Notes: SFs Compiled Version

Table of Contents

Section 4: Near-Term Responses in a Changing Climate

1.1 The Timing and Urgency of Climate Action

Deep, rapid and sustained mitigation and accelerated implementation of adaptation reduces the risks of climate change for humans and ecosystems. In modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot and in those that limit warming to 2°C (>67%) and assume immediate action, global GHG emissions are projected to peak in the early 2020s followed by rapid and deep reductions. As adaptation options often have long implementation times, accelerated implementation of adaptation, particularly in this decade, is important to close adaptation gaps. (*high confidence*)

The magnitude and rate of climate change and associated risks depend strongly on near-term mitigation and adaptation actions (*very high confidence*). Global warming is *more likely than not* to reach 1.5°C between 2021 and 2040 even under the very low GHG emission scenarios (SSP1-1.9), and *likely* or *very likely* to exceed 1.5°C under higher emissions scenarios[84]. Many adaptation options have medium or high feasibility up to 1.5°C (*medium to high confidence*, depending on option), but hard limits to adaptation have already been reached in some ecosystems and the effectiveness of adaptation to reduce climate risk will decrease with increasing warming (*high confidence*). Societal choices and actions implemented in this decade determine the extent to which medium- and long-term pathways will deliver higher or lower climate resilient development (*high confidence*). Climate resilient development prospects are increasingly limited if current greenhouse gas emissions do not rapidly decline, especially if 1.5°C global warming is exceeded in the near-term (*high confidence*). Without urgent, effective and equitable adaptation and mitigation actions, climate change increasingly threatens the health and livelihoods of people around the globe, ecosystem health, and biodiversity, with severe adverse consequences for current and future generations (*high confidence*). {WGI SPM B.1.3, WGI SPM B.5.1, WGI SPM B.5.2; WGII SPM A, WGII SPM B.4, WGII SPM C.2, WGII SPM C.3.3, WGII Figure SPM.4, WGII SPM D.1, WGII SPM D.5, WGIII SPM D.1.1 SR1.5 SPM D.2.2}. (Cross-Section Box.2, Figure 2.1, Figure 2.3)

In modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot and in those that limit warming to 2°C (>67%), assuming immediate actions, global GHG emissions are projected to peak in the early 2020s followed by rapid and deep GHG emissions reductions (*high confidence*) [85]. In pathways that limit warming to 1.5°C (>50%) with no or limited overshoot, net global GHG emissions are projected to fall by 43% [34–60%][86] below 2019 levels by 2030,60% [49–77%] by 2035, 69% [58-90%] by 2040 and 84% [73-98%] (*high confidence*) (Section 2.3.1, Table 2.2, Figure 2.5, Table 3.1)[87]. Global modelled pathways that limit warming to 2°C (>67%) have reductions in GHG emissions below 2019 levels of 21% [1–42]% by 2030, 35% [22–55%] by 2035, 46% [34-63%] by 2040 and 64% [53-77%] by 2050 [88](*high confidence*). Global GHG emissions associated with NDCs announced prior to COP26 would make it *likely* that warming would exceed 1.5°C (*high confidence*) and limiting warming to 2°C (>67%) would then imply a rapid acceleration of emission reductions during 2030–2050, around 70% faster than in pathways where immediate action is taken to limit warming to 2°C (>67%) (*medium confidence*) (Section 2.3.1) Continued investments in unabated high-emitting infrastructure[89] and limited development and deployment of low-emitting alternatives prior to 2030 would act as barriers to this acceleration and increase feasibility risks (*high confidence*). {WGIII SPM B.6.3, WGIII Chapter 3.5.2, WGIII SPM B.6, WGIII SPM B.6., WGIII SPM C.1, WGIII SPM C1.1, Table SPM.2**}** (Cross-Section Box.2)

[84] In the near term (2021–2040), the 1.5°C global warming level is *very likely* to be exceeded under the very high GHG emissions scenario (SSP5-8.5), *likely* to be exceeded under the intermediate and high GHG emissions scenarios (SSP2-4.5, SSP3-7.0), *more likely than not* to be exceeded under the low GHG emissions scenario (SSP1-2.6) and *more likely than not* to be reached under the very low GHG emissions scenario (SSP1-1.9). The best estimates [and *very likely* ranges] of global warming for the different scenarios in the near-term are: 1.5°C [1.2°C–1.7°C] (SSP1-1.9); 1.5°C [1.2°C–1.8°C] (SSP1-2.6); 1.5°C [1.2°C–1.8°C] (SSP2-4.5); 1.5°C [1.2°C–1.8°C] (SSP3-7.0); and 1.6°C [1.3°C–1.9°C] (SSP5-8.5). {WGI SPM B.1.3, WGI Table SPM.1} (Cross-Section Box.2)

[85] Values in parentheses indicate the likelihood of limiting warming to the level specified (see Cross-Section Box.2).

[86] Median and *very likely* range [5th to 95th percentile] {WGIII SPM footnote 30}.

[87] These numbers for CO2 are 48% [36-69] in 2030, 65% [50-96%] in 2035, 80% [61-109%] in 2040 and 99 [79-119%] in 2050.

[88] These numbers for CO2 are 22% [1-44] in 2030, 37% [21-59%] in 2035, 51% [36-70%] in 2040 and 73 [55-90%] in 2050

[89] In this context, 'unabated fossil fuels' refers to fossil fuels produced and used without interventions that substantially reduce the amount of GHG emitted throughout the life cycle; for example, capturing 90% or more CO_2 from power plants, or 50–80% of fugitive methane emissions from energy supply {WGIII SPM footnote 54}.

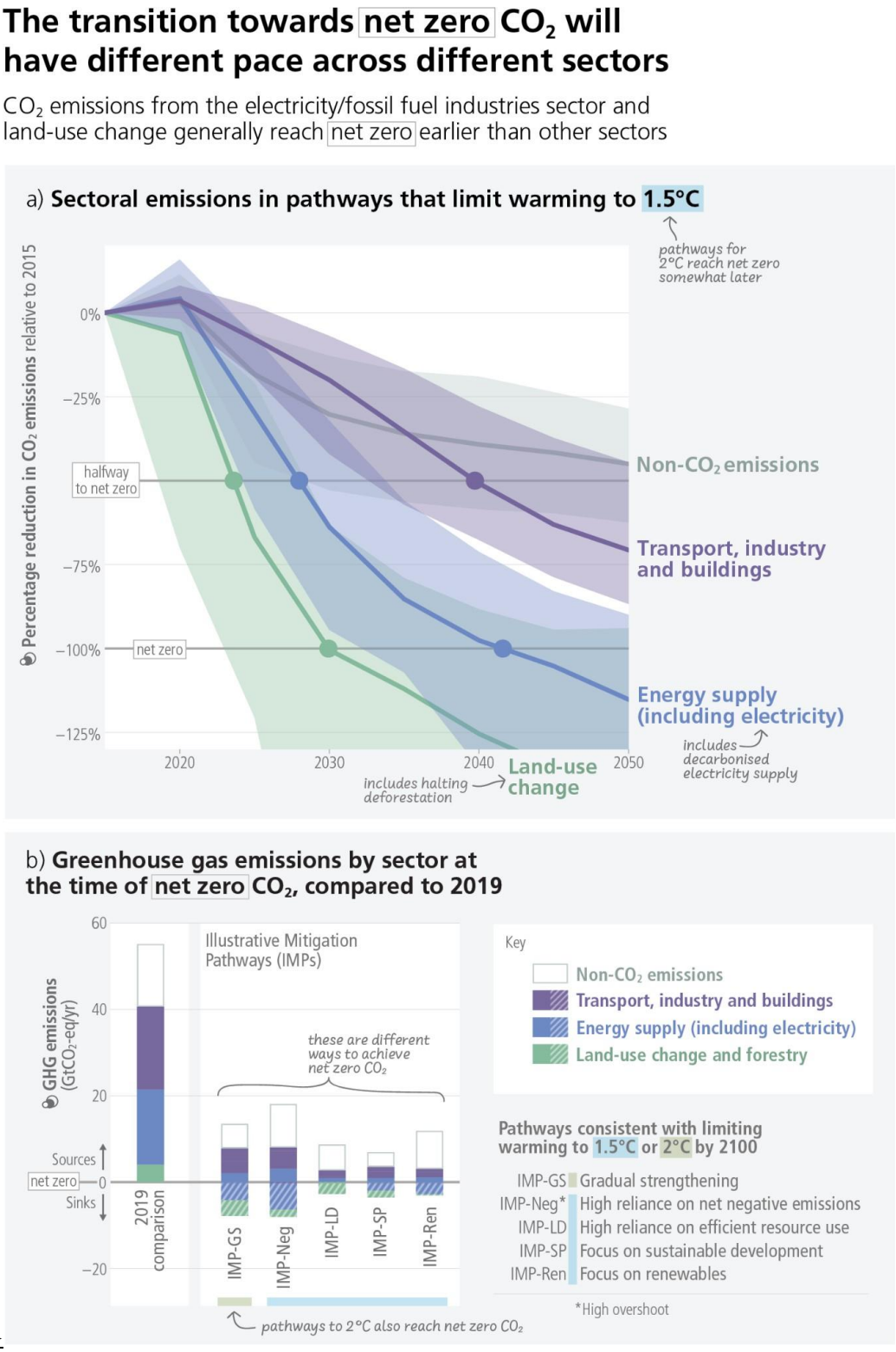
All global modelled pathways that limit warming to 2°C (>67%) or lower by 2100 involve reductions in both net CO_2 emissions and non-CO_2 emissions (see Figure 3.6) (*high confidence*). For example, in pathways that limit warming to 1.5°C (>50%) with no or limited overshoot, global CH_4 (methane) emissions are reduced by 34% [21–57%] below 2019 levels by 2030 and by 44% [31–63%] in 2040 (*high confidence*). Global CH_4 emissions are reduced by 24% [9–53%] below 2019 levels by 2030 and by 37% [20–60%] in 2040 in modelled pathways that limit warming to 2°C with action starting in 2020 (>67%) (*high confidence*). {WGIII SPM C1.2, WGIII Table SPM.2, WGIII Chapter 3.3; SR1.5 SPM C.1, SR1.5 SPM C.1.2} (Cross-Section Box.2)

All global modelled pathways that limit warming to 2°C (>67%) or lower by 2100 involve GHG emission reductions in all sectors (*high confidence*). The contributions of different sectors vary across modelled mitigation pathways. In most global modelled mitigation pathways, emissions from land-use, land-use change and forestry, via reforestation and reduced deforestation, and from the energy supply sector reach net zero CO_2 emissions earlier than the buildings, industry and transport sectors (Figure 4.1). Strategies can rely on combinations of different options (Figure 4.1, Section 4.5), but doing less in one sector needs to be compensated by further reductions in other sectors if warming is to be limited. (*high confidence*) {WGIII SPM C.3, WGIII SPM C.3.1, WGIII SPM 3.2, WGIII SPM C.3.3} (Cross-Section Box.2)

Without rapid, deep and sustained mitigation and accelerated adaptation actions, losses and damages will continue to increase, including projected adverse impacts in Africa, LDCs, SIDS, Central and South America[90], Asia and the Arctic, and will disproportionately affect the most vulnerable populations (*high confidence*). {WGII SPM C.3.5; WGII SPM B.2.4; WGII Global to Regional Atlas Annex A1.15, A1.27; WGII 12.2; WGII 10. Box 10.6; WGII TS D.7.5; WGII CCB6 ES; SR1.5 SPM B.5.3; SR 1.5 SPM B.5.7; SRCCL A.5.6} (Figure 3.2; Figure 3.3)

[START FIGURE 4.1 HERE]

[90] The southern part of Mexico is included in the climatic subregion South Central America (SCA) for WGI. Mexico is assessed as part of North America for WGII. The climate change literature for the SCA region occasionally includes Mexico, and in those cases WGII assessment makes reference to Latin America. Mexico is considered part of Latin America and the Caribbean for WGIII. {WGII 12.1.1,



WGIII AII.1.1}

Figure 4.1: Sectoral emissions in pathways that limit warming to 1.5°C. Panel (a) shows sectoral CO_2 and non-CO_2 emissions in global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot. The horizontal lines illustrate halving 2015 emissions (base year of the pathways) (dashed) and reaching net-zero emissions (solid line). The range shows the 5–95th percentile of the emissions across the pathways. The timing strongly differs by sector, with the CO_2 emissions from the electricity/fossil fuel industries sector and land-use change generally reaching net zero earlier. Non-CO_2 emissions from agriculture are also substantially reduced compared to pathways without climate policy but do not typically reach zero. **Panel (b)** Although all pathways include strongly reduced emissions, there are different pathways as indicated by the illustrative mitigation pathways used in IPCC WGIII. The pathways emphasise routes consistent with limiting warming to 1.5°C with a high reliance on net negative emissions (IMP-Neg), high resource efficiency (IMP-LD), a focus on sustainable development (IMP-SP) or renewables (IMP-Ren) and consistent with 2°C

based on a less rapid introduction of mitigation measures followed by a subsequent gradual strengthening (IMP-GS). Positive (solid filled bars) and negative emissions (hatched bars) for different illustrative mitigation pathways are compared to GHG emissions from the year 2019. The category "energy supply (including electricity)" includes bioenergy with carbon capture and storage and direct air carbon capture and storage. {WGIII Box TS.5, 3.3, 3.4, 6.6, 10.3, 11.3} (Cross-Section Box 2)

[END FIGURE 4.1 HERE]