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Long-term low-emission development strategies

Synthesis report by the secretariat

Summary

This synthesis report on long-term low-emission development strategies synthesizes information from the 53 latest available long-term low-emission development strategies, representing 62 Parties to the Paris Agreement, submitted to the secretariat as at 23 September 2022.

Contents

Abbreviations and acronyms

ACE	Action for Climate Empowerment
AFOLU	agriculture, forestry and other land use
AR	Assessment Report of the Intergovernmental Panel on Climate Change
BECCS	bioenergy with carbon capture and storage
CCS	carbon dioxide capture and storage
CCUS	carbon dioxide capture, use and storage
CH_4	methane
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
COP	Conference of the Parties
DACCS	direct air carbon capture and storage
EU	European Union
GDP	gross domestic product
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LT-LEDS	long-term low-emission development strategy(ies)
LULUCF	land use, land-use change and forestry
N_2O	nitrous oxide
NAP	national adaptation plan
NDC	nationally determined contribution
NF_3	nitrogen trifluoride
REDD+	reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest carbon stocks; sustainable management of forests; and enhancement of forest carbon stocks (decision 1/CP.16, para. 70)
SDG	Sustainable Development Goal
SF_6	sulfur hexafluoride
SR1.5	Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5 °C

I. Executive summary

1. This report has been prepared in response to the request from CMA 3 for the secretariat to prepare a synthesis report on LT-LEDS to be made available at CMA 4.[1] The report synthesizes information from the 53 latest available LT-LEDS, representing 62 Parties to the Paris Agreement, including 4 updated LT-LEDS from 4 Parties, communicated to the secretariat and published on the UNFCCC website as at 23 September 2022, covering 68 per cent of total global emissions in 2019, which are estimated at 52.6 Gt CO_2 eq without LULUCF[2] (and around 56.4 Gt CO_2 eq with LULUCF).

2. The Parties that communicated LT-LEDS together account for 83 per cent of global GDP, 47 per cent of the global population and around 69 per cent of total energy consumption in 2019, including some 80 per cent of coal consumption, some 73 per cent of natural gas consumption and some 65 per cent of oil consumption.

3. In addition, 22 Parties that have not communicated LT-LEDS provided quantifiable information on their long-term mitigation visions, strategies and targets for up to and beyond 2050 in their latest NDCs. When considered together with the Parties that communicated LT-LEDS, they account for 79 per cent of total global emissions, 90 per cent of global GDP, 69 per cent of the global population and around 79 per cent of total energy consumption in 2019, including some 92 per cent of coal consumption, some 77 per cent of natural gas consumption and some 74 per cent of oil consumption.

4. All LT-LEDS provided a clear development perspective and integrated climate change related aspects and objectives with development visions, priorities, principles or economic, social and environmental objectives. In this context, many[3] (50 per cent) LT-LEDS indicated a close linkage between the LT-LEDS and the Parties' national development plans and most (71 per cent) LT-LEDS referred to linkages with the SDGs. Almost all LT-LEDS considered multiple synergies and trade-offs between sustainable development, emission reduction and adaptation to climate change.

5. In all LT-LEDS, Parties underlined their commitment to achieving the long-term temperature goal of the Paris Agreement given climate change has already caused and will continue to cause challenges related to national development. Although most (75 per cent) LT-LEDS underlined the need for massive-scale transformation, well beyond incremental change, as a challenge for the transition to low-emission development pathways, especially in terms of financing, many Parties highlighted the importance of proactively seizing opportunities in the global shift to a low-emission economy with the aim of achieving sustainable and inclusive economic development.

6. Parties identified various synergies between socioeconomic development objectives and transition to a low-emission economy. Recognizing that transformational structural change will result in both positive and negative effects on economic and social development, many (57 per cent) LT-LEDS underlined Parties' commitment to just transition, with some (32 per cent) elaborating on the concept in a dedicated chapter. Of the 43 per cent of LT-LEDS that did not explicitly mention just transition, some (23 per cent) illustrated elements that are linked to just transition, such as fairness, equity and inclusiveness. In total, most (79 per cent) LT-LEDS contained information on just transition and related elements and examples.

7. Many (60 per cent) LT-LEDS provided information on macroeconomic assessments, including the impact on GDP; changes in sectoral economic outputs, employment and trade patterns; required levels of investment and government expenditure; tax revenue; economic

[1] Decision 1/CMA.3, para. 34.

[2] Unless otherwise noted, in this report global GHG emission totals exclude emissions from forestry and other land use or LULUCF but include emissions from international maritime transport and international aviation. GHG emissions refer to totals of CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 using global warming potentials with a 100-year time horizon, as presented in the AR6, and cover all sectors without LULUCF.

[3] The following terms are used in this report to indicate the percentage of LT-LEDS that mention particular information: "a few" for less than 10 per cent; "some" for 10–40 per cent; "many" for 41–70 per cent; "most" for 71–90 per cent; and "almost all" for more than 90 per cent.

impacts caused by climate change; and the socioeconomic costs and benefits of mitigation and adaptation measures. Parties tended to indicate a positive impact on GDP and employment.

8. Many (41 per cent) LT-LEDS referred to gender, including gender integration. Significant mentions of gender appear in some (21 per cent) LT-LEDS, including treating gender as a cross-sectoral issue and referring to using gender analysis or other tools in planning or implementation. In addition, some (20 per cent) contained limited mentions of gender, mostly referring to demographic data disaggregated by sex. The limited or lack of information on gender considerations and integration in most (79 per cent) LT-LEDS stands in contrast with the continued, increasing integration of gender in most (75 per cent) NDCs.

9. All LT-LEDS communicated a long-term mitigation goal, with almost all (94 per cent) referring to a quantifiable long-term mitigation goal and a few (6 per cent) describing policies and actions without a quantifiable long-term goal. The communicated time frames of quantifiable long-term mitigation goals vary, with 2050 communicated in most (87 per cent) LT-LEDS.

10. Many (62 per cent) LT-LEDS described long-term mitigation goals in terms of net zero GHG emissions, while a few (6 per cent) referred to net zero CO_2 emissions. The mitigation goal in some (15 per cent) cannot be classified as net zero GHG or net zero CO_2 emissions and some (19 per cent) did not refer to a concept related to net zero emissions and instead described absolute emission reduction levels compared with a base year or policies and actions without a quantifiable long-term mitigation goal.

11. According to the latest NDCs, recorded in the interim NDC registry as at 23 September 2022, the collective emissions of Parties[4] that communicated LT-LEDS are estimated at 30.1 (29.2–31.1) Gt CO_2 eq in 2030, 6 (3–9) per cent lower than in 2010 and 11 (8–14) per cent lower than in 2019. When also taking into account Parties that have not communicated LT-LEDS but indicated their long-term mitigation visions, strategies and targets in their latest NDCs, collective emissions of those Parties are estimated at 36.6 (34.9–38.4) Gt CO_2 eq in 2030, 2 (–3 to 7) per cent lower than in 2010 and 6 (2–11) per cent lower than in 2019.

12. The total emissions in 2050 of Parties that communicated LT-LEDS are estimated at 10.8 (9.3–12.3) Gt CO_2 eq, which is 66 (62–71) per cent lower than in 2010 and 68 (64–73) per cent lower than in 2019, while a certain lack of clarity on the scope and coverage of long-term mitigation goals as well as quantified levels of emissions and removals in communicated LT-LEDS made it difficult to quantify emissions (see chap. III.C.1 below). When also considering Parties that have not communicated LT-LEDS but provided quantifiable information on their long-term mitigation visions, strategies and targets in their latest NDCs, the total GHG emissions in 2050 are estimated at 14.2 (12.3–16.1) Gt CO_2 eq, which is 61 (55–65) per cent lower than in 2010 and 64 (59–69) per cent lower than in 2019, if all the pledges are implemented in full and on time.

13. Average per capita emissions of Parties that communicated LT-LEDS and Parties that have not communicated LT-LEDS but provided quantifiable information on their long-term mitigation visions, strategies and targets in their latest NDCs are estimated at 2.4 (2.1–2.7) t CO_2 eq for 2050. Compared with the global average per capita emissions of 6.8 t CO_2 eq in 2019, as well as the average per capita emissions of those Parties of 7.3 t CO_2 eq in 2019, the projected per capita emissions of that group of Parties is more consistent with the global average in scenarios that keep warming to likely below 2 °C (with over 67 per cent likelihood), which is around 2.2 (1.4–2.9) t CO_2 eq in 2050 as assessed by the IPCC. For scenarios of limiting warming to 1.5 °C (with 50 per cent likelihood) with no or limited overshoot (and net zero emissions in the second half of the century), the projected per capita emissions are 0.9 (0.0–1.6) t CO_2 eq in 2050.

14. Calculated on the basis of the projected 2030 and 2050 GHG emission levels of the Parties that communicated LT-LEDS and those that have not communicated LT-LEDS but provided quantifiable information on their long-term mitigation visions, strategies and targets

[4] Unless otherwise noted, in this report, collective emissions stated for a certain year represent the emissions produced in that year and not the cumulative amount for a certain time period.

in their latest NDCs, the average emission reduction rate per annum between 2019 and 2030 for this group of Parties is 0.2 Gt CO_2 eq, which is equivalent to 0.6 per cent of those Parties' emissions in 2019. The average emission reduction rate per annum for this group of Parties between 2030 and 2050 is estimated at 1.1 Gt CO_2 eq, which is equivalent to 2.9 per cent of those Parties' emissions in 2019.

15. If Parties were collectively to start reducing emissions in 2020 with a view to achieving their 2050 targets, and those reductions remained constant over the next three decades, the average emission reduction rate per annum between 2030 and 2050 would be 0.8 percentage points lower than currently foreseen; it is estimated at 2.1 (1.9–2.2) per cent of emissions in 2019 and equivalent to 0.8 Gt CO_2 eq/year.

16. Under the IPCC-assessed scenarios that limit warming to 1.5 °C with no or low (50 per cent chance) overshoot, GHG emissions are projected to decrease from 2019 levels by 43 (34–60) per cent by 2030, which accounts for around half of reductions foreseen by 2050. In the scenarios that limit warming to below 2 °C with a likely chance (over 67 per cent) with the start of mitigation action at 2020, emissions are projected to decrease by 27 (14–45) per cent by 2030, which accounts for more than one third of reductions foreseen by 2050. For Parties that communicated LT-LEDS and those that have not communicated LT-LEDS but provided quantifiable information on their long-term visions, strategies and targets in their latest NDC, according to their NDCs, emissions are estimated to be 6 (2–11) per cent lower in 2030 than in 2019, which means that it is assumed that most emission reductions foreseen by 2050 will occur after 2030.

17. Some (40 per cent) LT-LEDS indicated that LT-LEDS will guide the development and ambition of the Parties' subsequent NDCs, including by adopting new policies and actions beyond their current NDCs. A few (8 per cent) mentioned that the latest NDCs are already aligned with the LT-LEDS. In addition, some (17 per cent) LT-LEDS described a scenario that requires deeper emission reductions than the current NDCs. Many (49 per cent) LT-LEDS did not provide information on how they relate to the NDCs.

18. All LT-LEDS described mitigation measures to achieve their long-term mitigation goal that are often a subset of one or more IPCC sectors. All LT-LEDS communicated mitigation options in building, energy supply and transport, and almost all in the agriculture, industry, LULUCF and waste sectors.

19. The contribution of Working Group III to the AR6 indicated that mitigation options that cost USD 100/t CO_2 eq or less could reduce global emissions by at least half the 2019 level by 2030. The relative potential and cost of those options will vary across countries and in the longer term compared with in 2030. Most LT-LEDS provided information on several of these mitigation options in the context of their mitigation pathways. Most frequently, LT-LEDS contained information on ecosystem restoration, afforestation and reforestation (96 per cent); reduced CH_4 emissions from solid waste (96 per cent); electric light-duty vehicles (94 per cent); solar energy (91 per cent); shift to public transportation (91 per cent); and industry energy efficiency (91 per cent).

20. Considering the long lifetime of infrastructure and the risk of locked-in carbon- and energy-intensive assets, some LT-LEDS highlighted that action taken during the current NDC implementation period will determine a considerable number of activities and associated emissions and removals in mid-century.

21. Although there is uncertainty relating to technology development, energy prices and international trade patterns in the long term, many LT-LEDS included one or more quantitative targets on energy with a specific time frame to reflect long-term goals in near-term actions, for example:

(a) 45 per cent referred to clean power generation targets with target years ranging from 2027 to 2035, 2040 and 2050 and referred to them in various ways, including renewable energy power, carbon-free electricity and fully decarbonized power systems. In addition, 32 per cent referred to a 100 per cent clean power generation target;

(b) 40 per cent communicated a target for new passenger vehicle sales for low- or zero-emission vehicles such as electric vehicles or new energy and clean energy-powered vehicles, including 15 per cent that communicated a target of a 100 per cent sales share

ranging from 2035 to 2050. A total of 15 per cent of LT-LEDS provided information on phasing out the sale of cars with internal combustion engines that run on diesel or gasoline. In this regard, phasing out sales of fossil-fuel passenger vehicles by 2035–2050 is considered in the SR1.5 as a mitigation option that is relevant to aligning global emissions trajectories with 1.5 °C pathways;

(c) 43 per cent highlighted that newly constructed buildings are required to be near zero energy with a timeline of 2020, 2021, 2025 or 2050. The SR1.5 identified that requiring newly constructed buildings to be near zero energy by 2020 is relevant to aligning global emissions trajectories with 1.5 °C pathways;

(d) 21 per cent included a timeline for phasing out unabated coal power to produce electricity, including 13 per cent by 2030 as identified in the SR1.5, which is considered relevant to aligning global emissions trajectories with 1.5 °C pathways.

22. The contribution of Working Group III to the AR6 identified several AFOLU mitigation options as the only currently widely practised CO_2 removal options; however, their removal potential is limited owing to competition for other land uses. In this regard, Parties reported non-conventional CO_2 removal options. For example, 27 per cent of LT-LEDS mentioned BECCS as necessary to limit temperature increase but not immediately deployable, and 13 per cent mentioned DACCS as technology that may be used in the future should its cost be significantly reduced.

23. Most (81 per cent) LT-LEDS mentioned circular economy as an objective or guiding principle for their long-term low-emission development, particularly in the context of mitigation. Almost all LT-LEDS indicated specific elements described under the circular economy concept, including resource and material efficiency of industry (66 per cent), waste reuse (75 per cent) and waste recycling (91 per cent).

24. Almost all (98 per cent) LT-LEDS included adaptation-related information, in particular on climate change hazards and risks; vulnerability and impacts on priority sectors; adaptation-related policies, strategies, frameworks and plans; planned or implemented sectoral adaptation actions; synergies between adaptation and mitigation; and quantified adaptation targets for monitoring and evaluating adaptation progress.

25. Most (79 per cent) LT-LEDS provided information on key climatic changes, in particular increases in mean air temperature, precipitation changes and sea level rise. These were identified as triggering hazards and climate change impacts. The hazards include increases in frequency and intensity of drought, fluvial and coastal flooding, storms and tropical cyclones, heatwaves, extreme temperatures, heavy rainfall events, landslides, fires, ocean acidification and ocean temperature, as well as decreases in snow cover and sea ice.

26. Almost all (92 per cent) LT-LEDS provided an overview of national adaptation and resilience policies and strategies of developed countries, together with NAPs of developing countries. Some (38 per cent) LT-LEDS were linked to disaster risk reduction policies, national development plans and national mitigation and adaptation plans (particularly NDCs and NAPs).

27. Some (38 per cent) LT-LEDS stressed the importance of incorporating a just transition into their long-term adaptation plans and strategies. It was highlighted that a goal within the adaptation process should be to integrate gender and intergenerational approaches into adaptation measures, as well as promote inclusive indigenous people, citizen and stakeholder participation in the development and implementation of adaptation measures.

28. Adaptation priority sectors in LT-LEDS were typically aligned with priority sectors in NDCs. Terrestrial and wetland ecosystems (75 per cent of LT-LEDS), together with food security and production (74 per cent), which includes agriculture, livestock and fisheries, were the highest priority for adaptation, followed by key economic sectors and services (64 per cent), urban areas and human habitats (58 per cent), human health (45 per cent), freshwater resources (45 per cent), coastal and low-lying areas (40 per cent) and ocean ecosystems (19 per cent). Many (45 per cent) LT-LEDS emphasized the importance of designing and implementing nature-based solutions in building resilience and adaptation in priority sectors.

29. Many (62 per cent) LT-LEDS provided information on synergies between adaptation and mitigation actions, in particular in sectors related to terrestrial and wetland ecosystems, food security and production, and energy, with an emphasis that their adaptation and resilience efforts must be undertaken jointly with mitigation efforts.

30. Some (19 per cent) LT-LEDS included quantified targets covering all adaptation priority sectors. Most (81 per cent) LT-LEDS presented sectoral adaptation actions without quantifiable information that would allow monitoring of adaptation progress.

31. Most (85 per cent) LT-LEDS referred to financial needs for implementing LT-LEDS, with 26 per cent providing costed needs, 26 per cent describing finance needs qualitatively and 33 per cent providing general statements on needs. Some LT-LEDs identified funding sources for implementing LT-LEDS, such as domestic finance, international support and private finance. The submissions also provided information on efforts taken by the respective government to increase finance flows through economic policy measures, financing mechanisms or financial instruments, such as taxes, levies, fiscal incentives and carbon pricing mechanisms. Many (54 per cent) LT-LEDS stated the importance of making the financial flows consistent with a pathway towards low-emission and climate-resilient development, of which 21 per cent were from developing countries.

32. Many LT-LEDS reported strengthening of the Party's international cooperation to accelerate the deployment and application of cutting-edge, critical and disruptive technologies, including through joint planning and mainstreaming of technological innovation. The joint development of sustainable energy consumption technologies, including energy-saving and energy-efficiency technologies, delivers low-cost emission reduction measures with significant synergistic benefits in the medium and long term.

33. In general, LT-LEDS considered capacity-building as a cross-cutting issue that is the overarching enabler of adaptation and mitigation actions and commitments. In addition, the LT-LEDS highlighted the importance of capacity-building for facilitating technology development, access to climate finance, public engagement and transparent communication of information. Overall, LT-LEDS deemed capacity-building crucial to the implementation of the LT-LEDS operational strategy.

34. Many (42 per cent) LT-LEDS mentioned an intention to use voluntary cooperation, including the general use of voluntary cooperation under Article 6 of the Paris Agreement; use of cooperative approaches under Article 6, paragraph 2; use of the mechanism under Article 6, paragraph 4; and use of non-market approaches under Article 6, paragraph 8. A few (9 per cent) LT-LEDS indicated qualitative limits on their use of voluntary cooperation, including environmental integrity, transparency and avoidance of double counting of emission reductions. A few LT-LEDS mentioned the possibility of using offsetting to achieve the long-term net zero emissions goal.

35. Most (84 per cent) LT-LEDS indicated that institutional arrangements are crucial components for planning, coordinating and implementing climate change policy and action and for integrating climate change aspects into broader development planning. Some (12 per cent) referred to institutional arrangements specifically established for their LT-LEDS preparation and implementation.

36. Almost all (94 per cent) LT-LEDS highlighted that effective stakeholder engagement plays an important role in Parties' planning and implementation, as successful economic transformation requires a collective commitment to achieving the long-term goal by stakeholders. Most (75 per cent) LT-LEDS referred to stakeholder engagement during the preparation of LT-LEDS and most (90 per cent) referred to stakeholder engagement during the implementation of LT-LEDS.

37. Almost all (98 per cent) LT-LEDS provided information on using one or more ACE elements (such as climate education and public awareness, training, public participation, public access to information and international cooperation on the ACE elements) to ensure the effective implementation of mitigation and adaptation measures and acknowledged those elements as indispensable tools for mobilizing all sectors of society towards achieving the long-term goals. Parties recognized that the transition to a low-emission economy and society could only be achieved with a collective long-term vision in which all members of society,

including children and youth, are educated and empowered to make climate-conscious decisions and the current and future workforce is fully equipped with the skills necessary to address the climate crisis.

38. Most (82 per cent) LT-LEDS provided information on formal arrangements for monitoring and reporting on progress of LT-LEDS implementation. Some (26 per cent) LT-LEDS indicated requirements to report the implementation of measures annually and a few (9 per cent) indicated requirements to report every two years.

39. Most (85 per cent) LT-LEDS reported the intention of Parties to regularly update their LT-LEDS. Many (64 per cent) LT-LEDS referred to frequency of updates. Every five years was the most widely indicated timeline, representing many (42 per cent) LT-LEDS. In addition, some (40 per cent) LT-LEDS indicated that the timeline for reviewing and updating them is aligned with the timeline for updating NDCs, so that LT-LEDS will guide subsequent NDCs.

II. Mandate, scope and approach

A. Mandate

40. Under Article 4, paragraph 19, of the Paris Agreement, all Parties should strive to formulate and communicate LT-LEDS, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

41. COP 21 invited Parties to communicate, by 2020, to the secretariat mid-century, LT-LEDS and requested the secretariat to publish on the UNFCCC website Parties' LT-LEDS as communicated.[5]

42. CMA 3 urged Parties that had not yet done so to communicate, by CMA 4, LT-LEDS towards just transitions to net zero emissions by or around mid-century, taking into account different national circumstances.[6] It also invited Parties to update LT-LEDS regularly, as appropriate, in line with the best available science.[7]

43. CMA 3 requested the secretariat to prepare a synthesis report on LT-LEDS to be made available to CMA 4.[8]

B. Scope

44. This report synthesizes information from the 53 latest available LT-LEDS, representing 62 Parties to the Paris Agreement,[9] submitted to the secretariat and published on the UNFCCC website as at 23 September 2022.[10]

[5] Decision 1/CP.21, para. 35.
[6] Decision 1/CMA.3, para. 32.
[7] Decision 1/CMA.3, para. 33.
[8] Decision 1/CMA.3, para. 34.
[9] In addition to an LT-LEDS communicated by Croatia and the European Commission on behalf of the EU and its member States, 18 LT-LEDS were communicated by individual EU member States. For the purpose of synthesizing the information, the EU is considered as representing 28 Parties (27 member States plus the EU) with regard to information such as GHG emissions, GDP and energy consumption. Information from the LT-LEDS communicated on behalf of the EU and from the LT-LEDS of individual EU member States is considered separately to reflect the diversity of their content.
[10] See https://unfccc.int/process/the-paris-agreement/long-term-strategies.

C. Approach

45. This synthesis report contains the information communicated by Parties in their LT-LEDS and synthesized for all those Parties taken together.

46. The approach and methods for estimating projected emissions in chapter III.C.3 below are consistent with those in the most recent NDC synthesis report available.[11] Chapter III.C.3 below also considers the estimated emission projections of Parties that have not communicated LT-LEDS but provided quantifiable information on their long-term mitigation visions, strategies and targets in their latest NDCs.

47. The following terms are used in this report to indicate the percentage of LT-LEDS that mention particular information: "a few" for less than 10 per cent; "some" for 10–40 per cent; "many" for 41–70 per cent; "most" for 71–90 per cent; and "almost all" for more than 90 per cent.

III. Synthesis of information contained in long-term low-emission development strategies

A. Overview of the communicated long-term low-emission development strategies

48. This report considers the 53 latest available LT-LEDS, representing 62 Parties to the Paris Agreement, including 4 updated LT-LEDS from 4 Parties, communicated to the secretariat and published on the UNFCCC website as at 23 September 2022, covering 68 per cent of total global emissions in 2019, which are estimated at 52.6 Gt CO_2 eq without LULUCF[12] (and around 56.4 Gt CO_2 eq with LULUCF[13]).

49. The Parties that communicated LT-LEDS together account for 83 per cent of global GDP,[14] 47 per cent of the global population[15] and around 69 per cent of total energy consumption in 2019, including some 80 per cent of coal consumption, some 73 per cent of natural gas consumption and some 65 per cent of oil consumption[16] (see figure 1).

50. In addition, 22 Parties that have not communicated LT-LEDS provided quantifiable information on their long-term mitigation visions, strategies and targets for up to and beyond 2050 in their latest NDCs. Total emissions of those Parties and Parties that communicated LT-LEDS in 2019 are estimated at 39.1 Gt CO_2 eq, covering 79 per cent of total global emissions, 90 per cent of global GDP,[17] 69 per cent of the global population[18] and around 79 per cent of total energy consumption in 2019, including some 92 per cent of coal consumption, some 77 per cent of natural gas consumption and some 74 per cent of oil consumption[19] (see figure 1).

[11] FCCC/PA/CMA/2022/4.

[12] Including emissions from countries that are not Parties to the Paris Agreement. A harmonization factor is used to ensure comparability with Shared Socioeconomic Pathway scenarios assessed by the IPCC and emissions from international aviation and maritime transport, which respectively accounted for approximately 1.2 and 1.5 per cent of total global emissions in 2019.

[13] In line with anthropogenic land-use emissions and removals in scenarios assessed by the IPCC, although actual directly induced net emissions from LULUCF could be higher.

[14] GDP at current prices based on United Nations Statistics Division data. See https://data.un.org/_Docs/SYB/PDFs/SYB64_230_202110_GDP%20and%20GDP%20Per%20Capita.pdf.

[15] See the United Nations 2019 Revision of World Population Prospects at https://population.un.org/wpp/Download/Standard/Population/.

[16] Estimated on the basis of data from IEA. 2022. *World Energy Balances*. Paris: IEA. All rights reserved; as modified by the secretariat. IEA data used in this report are subject to IEA terms and conditions, available at www.iea.org/terms.

[17] As footnote 14 above.

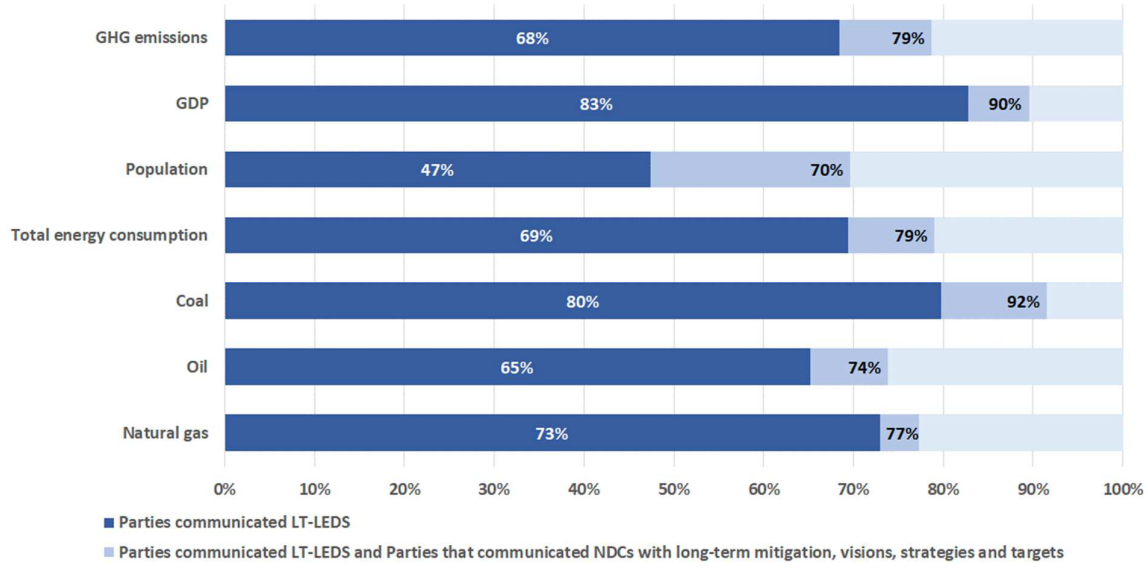
[18] As footnote 15 above.

[19] As footnote 16 above.

51. In total, 28 LT-LEDS were communicated as at December 2020, 26 in 2021, including 4 updated LT-LEDS, and 3 LT-LEDS in 2022, as at 23 September.

Figure 1

Share of global emissions, gross domestic product, population, and total energy, coal, oil and natural gas consumption in 2019 for Parties that communicated long-term low-emission development strategies and long-term mitigation visions, strategies and targets in their nationally determined contributions



B. Long-term low-emission development pathways and development priorities

1. Linking long-term low-emission development with socioeconomic development

52. All LT-LEDS provided a clear development perspective to frame their LT-LEDS and integrated climate change related aspects and objectives with development visions, priorities and principles or economic, social and environment objectives.

53. In this context, many (50 per cent) LT-LEDS indicated the close linkage between the LT-LEDS and Parties' national development plans and most (71 per cent) LT-LEDS referred to linkages with the SDGs.

54. Almost all LT-LEDS considered multiple synergies and trade-offs among sustainable development, emission reductions and adaptation to climate change. In all LT-LEDS, Parties underlined their commitment to achieving the long-term temperature goal of the Paris Agreement given climate change has already caused and will continue to cause challenges related to national development. Although most (75 per cent) LT-LEDS underlined the need for massive-scale transformation well beyond incremental change as a challenge for the transition to a low-emission development pathway, especially in terms of financing, many Parties highlighted the importance of proactively seizing opportunities from the global shift to a low-emission economy with the aim of achieving sustainable and inclusive economic development.

55. In some LT-LEDS, Parties highlighted that the LT-LEDS formulation process provided an opportunity for Parties to identify a series of changes across the economy required over time with a view to exploiting benefits and managing challenges for a just transition.

56. In this context of changes required over time, Parties noted, for example, that promoting new industries such as clean hydrogen will create new export markets and jobs, which will help to offset the long-term impacts in sectors such as thermal coal and natural gas, for which the demand may change due to shifting choices of international consumers; that the net impact of the transition to a low-emission economy depends on actual policies

pursued and the rate and size of the change, while the total number of potential synergies between cutting emissions and achieving other societal goals generally exceeds the number of conflicts; that LT-LEDS aim to serve as a road map or vision document based on comprehensive analysis and modelling of all relevant economic sectors and outline priority mitigation actions for each sector needed to achieve the country's goal of a carbon-neutral economy by 2050, taking into account the balance among emission reductions, economic growth, social justice and climate resilience; and that more than one path can be taken towards a climate-neutral future and there is more than one way to achieve a climate-neutral society as seen from the multiple emissions scenarios and projections in many (60 per cent) LT-LEDS (see chapter III.C.2 below).

(a) Synergies

57. Parties identified various synergies between socioeconomic development objectives and transition to a low-emission economy. In total, 91 per cent of LT-LEDS highlighted synergies with economic growth, 83 per cent with job creation, 75 per cent with social welfare and human well-being with reduced inequalities, 75 per cent with improved business and industry competitiveness, 72 per cent with better human health including through improved air quality, 72 per cent with sustainable cities, 68 per cent with climate resilience and disaster risk reduction, 62 per cent with sustainable consumption and production including through a circular economy, 60 per cent with long-term development planning such as infrastructure development, 57 per cent with biodiversity, 57 per cent with affordable and clean energy with improved energy security, 54 per cent with innovation and technology development, 48 per cent with food security and quality, and 30 per cent with economic diversification. Other areas of synergy outlined in LT-LEDS include improved trade balance with fewer energy imports, reduced dependence on imported materials including fossil fuels, reduced energy poverty, reduced traffic congestion and travel time owing to efficient public passenger mobility, improved travel options for non-vehicle owners that enable social and economic participation, improved safety in transportation, improved use of public space, improved health due to more cycling and walking, more convenient and comfortable housing, increased rural development, an increase in the number of healthy and climate-resilient forests, more water conservation, and more countries with nearly zero waste.

58. The synergies described in LT-LEDS correspond to many elements of the SDGs, with SDG 8 (decent work and economic growth) most frequently mentioned, followed by SDG 17 (partnerships for the goals), SDG 9 (industry, innovation and infrastructure), SDG 10 (reduced inequalities), SDG 11 (sustainable cities and communities), SDG 3 (good health and well-being), SDG 4 (quality education) and SDG 12 (responsible consumption and production) (see figure 2).

Figure 2
Synergies between long-term low-emission development and elements of the Sustainable Development Goals mentioned in long-term low-emission development strategies

Note: The shading reflects how frequently linkages were identified by Parties: the darker the shading, the more frequently linkages were identified.

(b) Challenges

59. Challenges described in LT-LEDS illustrate the common threat of climate change on national development and different national circumstances, including social, economic and political conditions and capabilities. Many (75 per cent) LT-LEDS underlined challenges concerning uncertainty in technology development, including cost and availability; 65 per cent highlighted challenges relating to finance, including safeguarding sound and balanced public finance and access to new sources of finance; and 46 per cent referred to energy

affordability and reliability. Additional challenges included food security (45 per cent), a smooth transition away from carbon-intensive sectors (40 per cent), protection of biodiversity and the environment (40 per cent), stakeholder engagement (23 per cent), dependence on foreign energy and resources (21 per cent), socioeconomic transition in a short period of time (19 per cent), phasedown of assets with a long lifetime (19 per cent), carbon leakage (17 per cent) and lack of capacity (15 per cent). Other challenges indicated in fewer LT-LEDS included widespread poverty, high unemployment, a high fiscal deficit, political instability, armed conflicts and migratory pressures.

60. A few LT-LEDS reported a negative impact on GDP and underlined that policy planning and technology cost reduction is needed to mitigate it (see chapter III.E.2 below for challenges related to risks, vulnerability and impacts of climate change).

61. Common challenges in reducing emissions from the energy sector communicated in LT-LEDS include the significant amount of new zero-carbon electricity capacity required; development of new energy transmission, distribution and storage infrastructure to flexibly respond to changes in supply and demand when deployment of solar and wind power is increased; the high cost of electric vehicles; alternate sources of low-carbon fuels for long-distance transport such as aviation; the long lifetime of buildings with high upfront costs for energy-efficiency improvements; and decarbonization of high-temperature heat required for industrial processes including cement production.

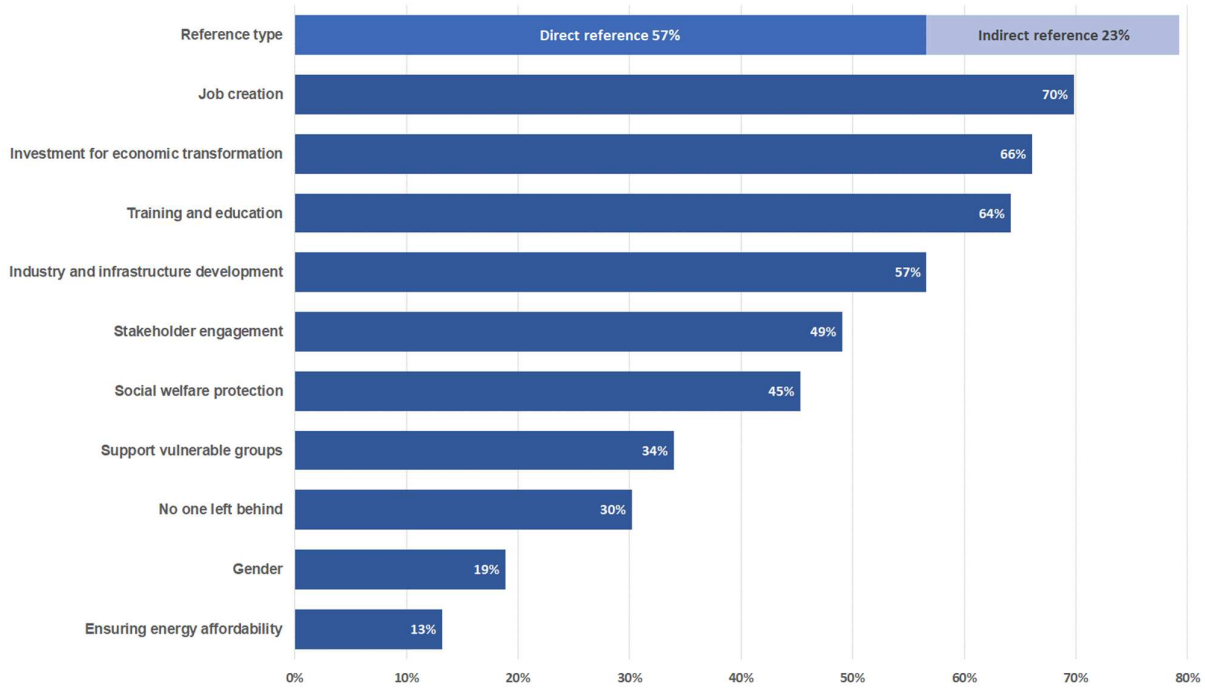
62. A major challenge for the AFOLU sector to contribute to mitigating climate change is competing land-use options, as many (68 per cent) LT-LEDS mentioned the need to balance competing demands of multiple land uses on limited land, noting that the objectives of ensuring food security, providing renewable raw materials and protecting the environment, as well as combating climate change, must all be coordinated. In this context, many (42 per cent) LT-LEDS noted the need for safeguards to limit unwanted social or environmental effects of LT-LEDS, for example related to biodiversity loss or food security.

2. Just transition

63. CMA 3 highlighted the importance of just transition in the context of LT-LEDS when moving towards net zero emissions by or around mid-century.

64. Recognizing that transformational structural change will result in both positive and negative effects on economic and social development, including jobs, many (57 per cent of) LT-LEDS underlined Parties' commitment to just transition, with some (32 per cent) elaborating on the concept in a dedicated chapter. Of the 43 per cent of LT-LEDS that did not explicitly mention just transition, some (23 per cent) illustrated elements that are linked with just transition, such as fairness, equity and inclusiveness. In total, most (79 per cent) LT-LEDS contained information on just transition and related elements and examples (see figure 3).

Figure 3
Common elements of just transition described in long-term low-emission development strategies



65. In the context of just transition, many (55 per cent) LT-LEDS described policy options to provide new economic and employment opportunities for relevant sectors and people affected by the required transition. Examples include providing training opportunities for employment, such as upskilling and reskilling professionals, lifelong learning and mainstreaming climate change in educational curricula, so that current and future generations are able to cope with societal transitions and rapidly changing labour-market needs; providing adequate instruments, incentives, support and direct investments to foster job creation in growing markets; considering social measures for unemployed workers, such as unemployment insurance, job relocation and early retirement; developing financial instruments, such as carbon pricing, to help generate revenues that can be reinvested; developing infrastructure such as transport and telecommunications to enable industry growth; and setting effective measures to tackle carbon leakage.

66. Albeit with different levels of detail, many (55 per cent) LT-LEDS include information on processes and steps needed to ensure a well-managed just transition, including ad hoc national commissions, task forces and overarching strategies. Parties underlined that analysing the possible impacts of the socioeconomic transformation, its consequences and opportunities, including new jobs and markets, provides a basis for a vision and just transition scenarios from which policies will be developed with differentiated scales and speeds tailored to national and regional contexts. In this regard, a continued and inclusive dialogue with stakeholders (particularly those in affected sectors), workers and other vulnerable groups was considered a crucial component by Parties. In addition, monitoring indicators to track progress and preparing regular updates were mentioned as effective ways to ensure just transition over time.

3. Macroeconomic effect

67. Parties assessed macroeconomic effects resulting from the transition to a low-emission economy, with an aim of anticipating possible challenges and opportunities. In this context, many (60 per cent) LT-LEDS provided information on macroeconomic assessments, including the impact on GDP; changes in sectoral economic outputs, employment and trade patterns; required level of investment and government expenditure; tax revenue; economic

impacts caused by climate change; and socioeconomic costs and benefits of mitigation and adaptation measures such as cost saving from less energy use.

68. Many (45 per cent) LT-LEDS provided information on a quantitative impact on GDP and some (38 per cent) provided information on a quantitative impact on employment. Parties tended to indicate a positive impact on GDP and employment, while a few reported a negative impact on GDP and underlined a need for policy planning and technologies cost reduction in order to mitigate the negative impact. A few LT-LEDS mentioned that the assessment did not take into account economic benefits of mitigation from avoided damage from climate change or from reduced adaptation costs. A few LT-LEDS communicated the estimated impact on employment by sector and gender. LT-LEDS tended to indicate new employment opportunities as a part of macroeconomic assessment, while the need for job creation, training and education was highlighted in the context of just transition (see chapter III.B.2 above)

69. Many (45 per cent) LT-LEDS reported assessments on required levels of investment, typically indicating substantial levels of long-term investment that are considered both a cost and an input to GDP growth and job creation (see chapter III.F.1 below for more information on finance).

70. Possible impacts on international trade were mentioned in many (57 per cent) LT-LEDS, including new trade opportunities arising from a global transition to a low-emission economy, cost savings from decreased fuel imports and a need for export diversification.

71. Although some LT-LEDS included analytical tools for macroeconomic effect assessment, uncertainties on key issues complicated a granular description of all macroeconomic implications, including future commodity prices, technology costs and consumer behaviour.

4. Gender

72. Many (41 per cent) LT-LEDS referred to gender, including gender integration. Significant mentions[20] of gender appear in some (21 per cent) LT-LEDS, including treating gender as a cross-sectoral issue and references to gender analysis or other tools used in planning or implementation. In addition, some (20 per cent) LT-LEDS contained limited mentions of gender, mostly referring to demographic data disaggregated by sex. The limited or lack of information on gender considerations and integration in most (79 per cent) LT-LEDS stands in contrast with the continued, increasing integration of gender in most (75 per cent) NDCs.

73. The Parties whose LT-LEDS contained significant mentions of gender also included significant mentions of gender in their NDC, whereas the Parties whose LT-LEDS contained limited references to gender included more references to gender in their NDC. Most Parties that did not mention gender in their LT-LEDS did mention it in their NDCs.

74. Of the Parties that referred to gender in their LT-LEDS, many did so in the context of gender balance and women's participation and leadership, including describing the engagement of women in programmes and strategies, with some in the context of adaptation or in a cross-sectoral manner.

C. Long-term mitigation goal

1. Type and time frame, scope and coverage, and net zero emissions

(a) Type and time frame

75. All LT-LEDS communicated a long-term mitigation goal, taking into account different national circumstances. The mitigation goals vary and are often described

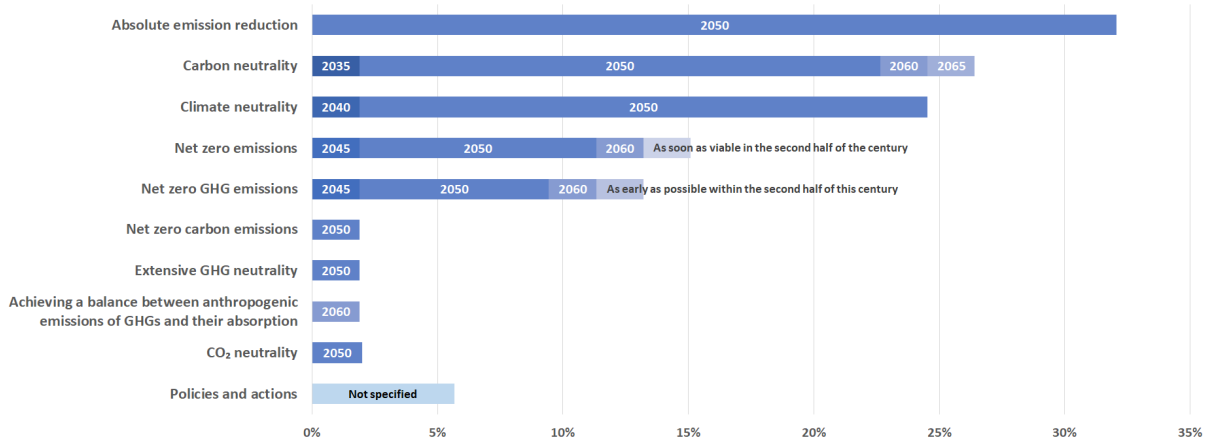
[20] See document FCCC/CP/2022/6 for further details on the categorization of gender mentions. For example, communications classified as making "limited" mention of gender were often limited to demographic data, whereas communications classified as making "significant" mention of gender treated it as a cross-sectoral issue and/or referenced gender analysis or other tools.

differently, including as commitments enshrined in national legislation or aspirational goals, conditional on international support, as an expression of intention to move towards net zero carbon emissions over time or as a guiding principle.

76. Also, Parties used different terminologies to express their long-term mitigation goals, including targets for net zero emissions, carbon neutrality, climate neutrality, achieving a balance between anthropogenic emissions of GHGs and their absorption and absolute emission reduction level compared with a base year. Figure 4 summarizes the long-term mitigation goals and time frames.

77. Almost all (94 per cent) LT-LEDS indicated a quantifiable long-term mitigation goal and a few (6 per cent) described policies and actions without a quantifiable long-term goal. The communicated time frames of quantifiable long-term mitigation goals vary, including 2035, 2040, 2045, 2050, 2060 and 2065. The most widely communicated time frame was 2050, indicated in most (87 per cent) LT-LEDS. Some (11 per cent) LT-LEDS indicated multiple time frames corresponding to long-term goals, such as an absolute emission reduction target for 2050 with a view to reaching net zero emissions thereafter and a combination of net zero CO_2 emission targets and absolute emission reduction targets on non-CO_2 gases.

Figure 4
Types and time frames of long-term mitigation goals communicated in long-term low-emission development strategies



Note: The number of long-term mitigation goals exceeds the number of LT-LEDS in the figure, resulting in an overall percentage of more than 100 per cent. For the purpose of analysis, multiple long-term mitigation goals in one LT-LEDS were counted separately. For example, when a Party included an absolute emission reduction target by 2050 and net zero emissions at a later date, both are counted in the figure.

(b) Scope and coverage of sector and greenhouse gases

78. Many LT-LEDS indicated that their long-term mitigation goal covers all sectors. Although a clear description of sector coverage is often not explicitly communicated in the LT-LEDS, Parties outlined efforts to address emissions from multiple sectors corresponding to IPCC sectors, IPCC subsectors or combinations thereof. Almost all LT-LEDS had a chapter or section on agriculture, energy supply, LULUCF and transport, most LT-LEDS highlighted energy, industry and waste, and many LT-LEDS included information on buildings. In addition, a few (4 per cent) LT-LEDS indicated that their long-term mitigation goal covers emissions from international aviation, shipping or both.

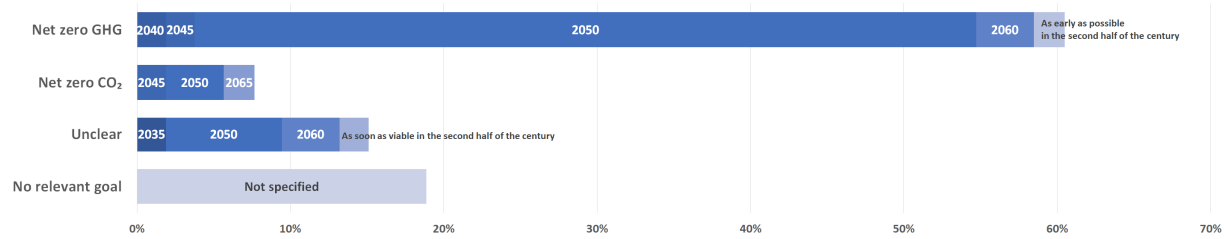
79. Many LT-LEDS indicated that their long-term mitigation goal covers all GHGs. A few LT-LEDS communicated multiple long-term goals tailored to different GHGs, including a combination of a net zero CO_2 emission target and an absolute emission reduction target for CH_4 and N_2O. Although LT-LEDS often did not include a clear description of GHG coverage in the context of presenting their overall long-term mitigation goal, all LT-LEDS mentioned efforts and activities to reduce CO_2, most did for CH_4, many for N_2O and hydrofluorocarbons, some for perfluorocarbons and SF_6 and a few for NF_3.

(c) Net zero emissions

80. The contribution of Working Group III to the AR6 considered a timeline of net zero CO_2 emissions and net zero emissions in global modelled pathways that limit global warming consistent with the long-term temperature goal of the Paris Agreement.

81. While Parties often used similar terminology to describe their long-term mitigation goals (see para. 76 above), the scope and coverage of these goals sometimes differed. Many (62 per cent) LT-LEDS described long-term mitigation goals in terms of net zero GHG emissions, while a few (6 per cent) referred to net zero CO_2 emissions. The mitigation goal in some (15 per cent) cannot be classified as net zero GHG or net zero CO_2 emissions, and some (19 per cent) did not refer to a concept related to net zero emissions and instead described absolute emissions reduction levels compared with a base year or policies and actions without a quantifiable long-term mitigation goal (see figure 5).

Figure 5
Share of net zero emissions references and time frame indicated in long-term low-emission development strategies



Note: The total percentage exceeds 100 per cent. For the purpose of analysis, multiple long-term mitigation goals in a single LT-LEDS were counted separately. For example, when a Party included both net zero CO_2 emissions and net zero GHG emissions with different time frames, both are counted in the figure.

2. Scenarios and projections of emissions and removals

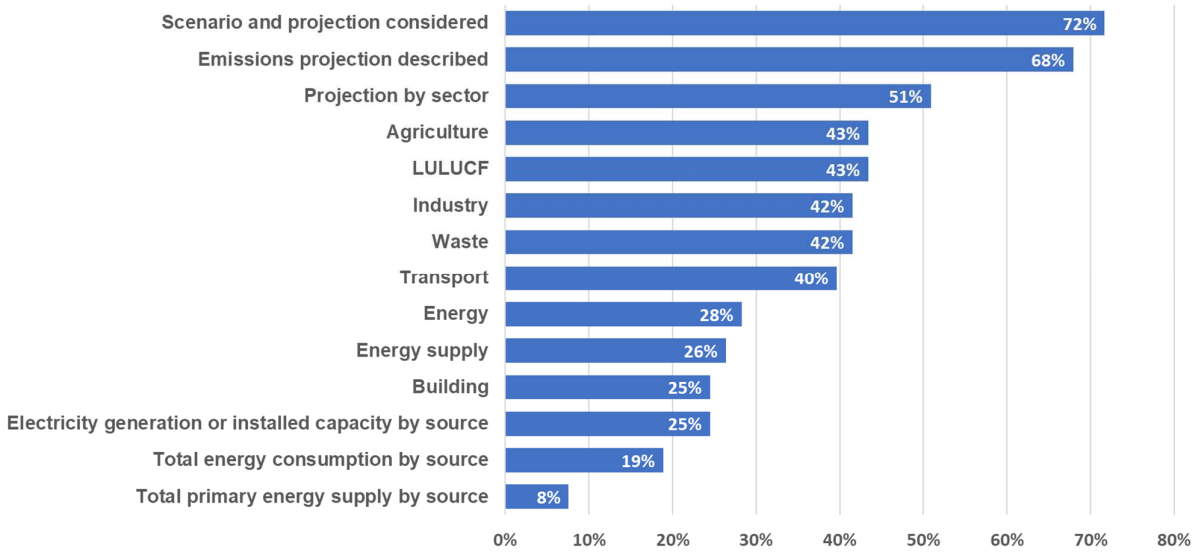
82. Many (72 per cent) LT-LEDS indicated that Parties considered emissions scenarios and projections while preparing their LT-LEDS. In addition, a few (8 per cent) LT-LEDS indicated that Parties will develop an emissions scenario as a follow-up to their LT-LEDS.

83. Figure 6 provides an overview of references to emissions scenarios and projections in the LT-LEDS. The number of scenarios described ranged from 1 to 12. Many (60 per cent) LT-LEDS described multiple scenarios for considering different pathways of technology development and interdependency among sectors, such as the share of renewable energy in electricity production and electrification rate of energy end-use sectors. In addition, many (53 per cent) LT-LEDS reported a scenario based on 'business as usual' and 'with existing measures' to identify additional policy interventions required to achieve Parties' long-term mitigation goal.

84. Many (68 per cent) LT-LEDS described projections of emissions and removals, including 51 per cent by sector and 9 per cent by GHG. Common sector categories in projections included agriculture, buildings, energy, energy supply, industry, LULUCF, transport and waste, which align with IPCC GHG inventory categories, sectors and subsectors. In addition, some (36 per cent) showed the level of removals in projections. The number of modelling tools mentioned ranged from one to six, including the computable general equilibrium model, The Integrated Market Allocation–Energy Flow Optimization Model System and the Low Emissions Analysis Platform.

85. Some (28 per cent) LT-LEDS described projections with a focus on energy, including electricity generation or installed capacity by source, total energy consumption by source and total primary energy supply by source.

Figure 6
Scenarios and projections of emissions and removals mentioned in long-term low-emission development strategies



3. Projected collective emissions taking into account implementation of long-term low-emission development strategies and nationally determined contributions

86. Total emissions in 2010 and 2019 of Parties that communicated LT-LEDS are estimated to be 32.1 and 34.0 Gt CO_2 eq, covering 72 and 68 per cent respectively of total global emissions. In addition, 22 Parties that have not communicated LT-LEDS provided quantifiable information in their latest NDCs on their long-term mitigation visions, strategies and targets for up to and beyond 2050.[21] When combined, the total emissions in 2010 and 2019 are estimated at 36.0 and 39.1 Gt CO_2 eq, covering 80 and 79 per cent of total global emissions in 2010 and 2019 respectively.[22]

87. According to the latest NDCs recorded in the NDC registry[23] as at 23 September 2022, the collective emissions of those Parties that communicated LT-LEDS are estimated at 30.1 (29.2–31.1) Gt CO_2 eq in 2030, 6 (3–9) per cent lower than in 2010 and 11 (8–14) per cent lower than in 2019. When also taking into account those Parties that have not communicated LT-LEDS but indicated their long-term mitigation visions, strategies and targets in their latest NDCs, collective emissions of those Parties are estimated at 36.6 (34.9–38.4) Gt CO_2 eq in 2030, 2 (–3 to 7) per cent lower than in 2010 and 6 (2–11) per cent lower than in 2019.

88. The total emissions in 2050 of Parties that communicated LT-LEDS are estimated at 10.8 (9.3–12.3) Gt CO_2 eq, which is 66 (62–71) per cent lower than in 2010 and 68 (64–73) per cent lower than in 2019, while a certain lack of clarity on the scope and coverage of long-term mitigation goals as well as quantified levels of emissions and removals in communicated LT-LEDS made it difficult to quantify emissions (see chap. III.C.1 above). When also considering Parties that have not communicated LT-LEDS but provided quantifiable information on their long-term mitigation visions, strategies and targets in their latest NDCs, the total GHG emissions in 2050 are estimated at 14.2 (12.3–16.1) Gt CO_2 eq, which is 61 (55–65) per cent lower than in 2010 and 64 (59–69) per cent lower than in 2019, if all the pledges are implemented in full and on time.

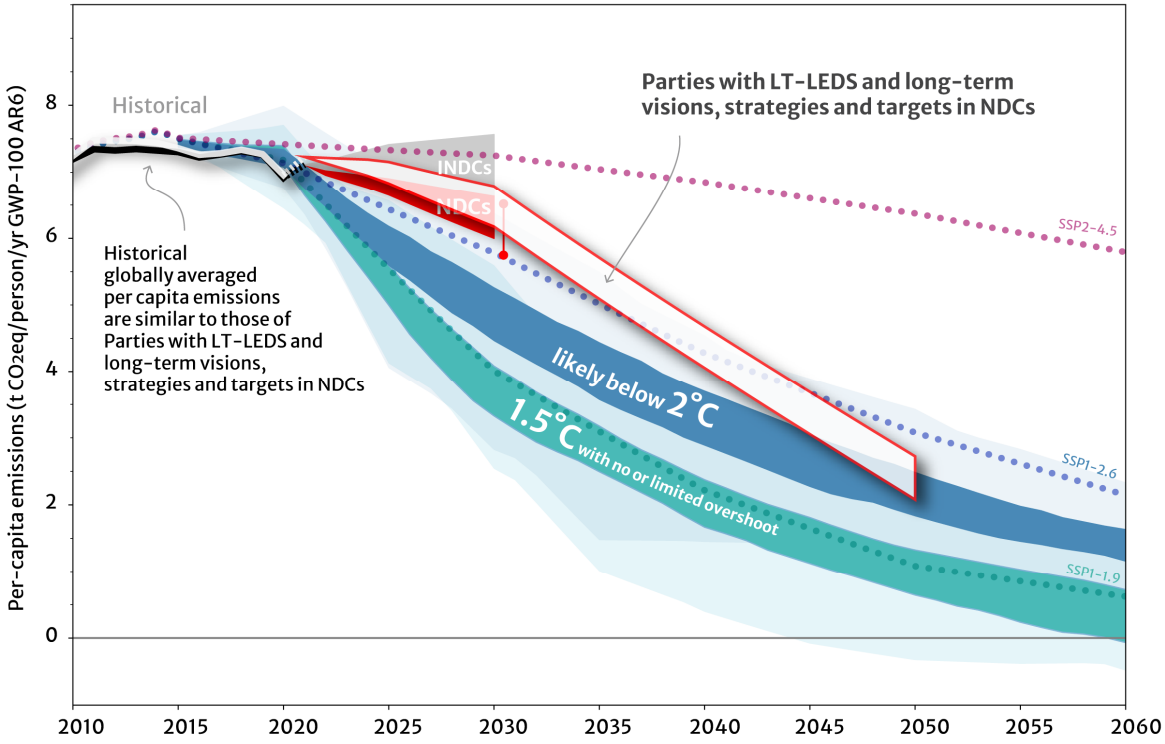
89. Average per capita emissions of Parties that communicated LT-LEDS and Parties that have not communicated LT-LEDS but provided quantifiable information on their long-term mitigation visions, strategies and targets in their latest NDCs are estimated at 2.4 (2.1–2.7) t

[21] FCCC/PA/CMA/2022/4.
[22] Furthermore, a number of other Parties announced their intention to achieve net zero emissions or carbon neutrality by or around mid-century, but their projected emissions are not considered in this report.
[23] https://unfccc.int/NDCREG.

CO_2 eq for 2050. Compared with the global average per capita emissions of 6.8 t CO_2 eq in 2019 as well as the average per capita emissions of those Parties of 7.3 t CO_2 eq in 2019, the projected per capita emissions of that group of Parties is more consistent with the global average in scenarios that keep warming to likely below 2 °C (with over 67 per cent likelihood), which is around 2.2 (1.4–2.9) t CO_2 eq in 2050 as assessed by the IPCC.[24] For scenarios of limiting warming to 1.5 °C (with 50 per cent likelihood) with no or limited overshoot (and net zero emissions in the second half of the century), the projected per capita emissions are 0.9 (0.0–1.6) t CO_2 eq in 2050 (see figure 7).

Figure 7

Comparison of per capita global greenhouse gas emissions based on long-term low-emission development strategies and nationally determined contributions with long-term mitigation visions, strategies and targets and emissions in Intergovernmental Panel on Climate Change scenarios



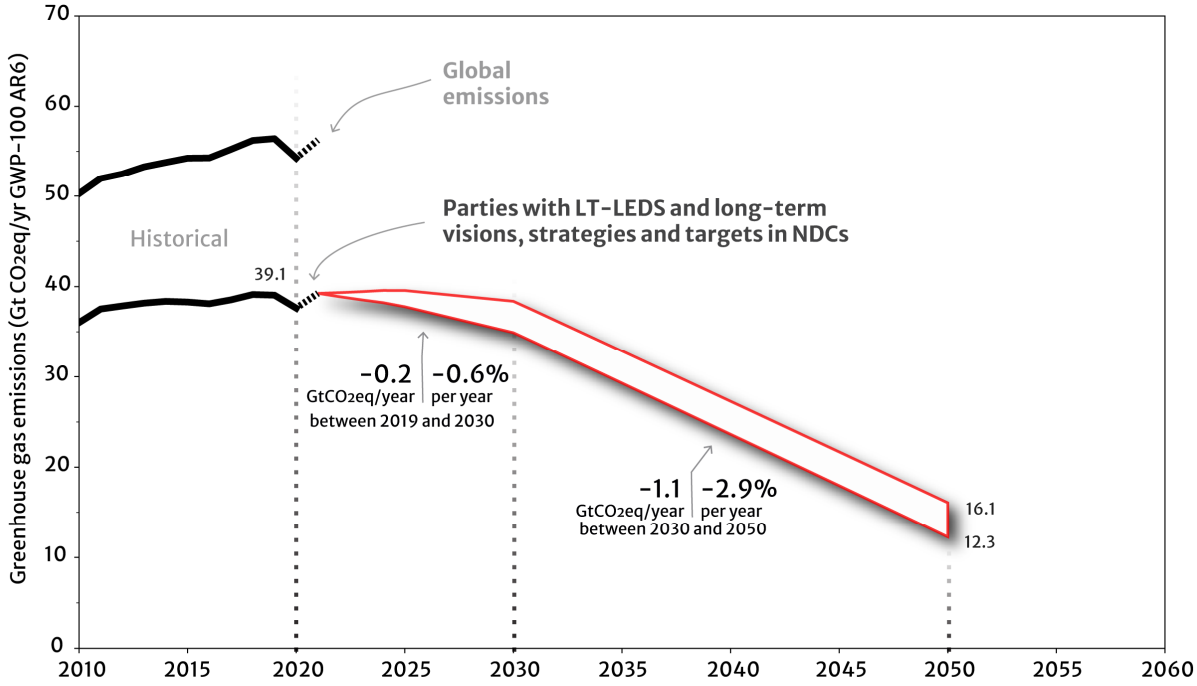
90. Calculated on the basis of the projected 2030 and 2050 GHG emission levels of the Parties that communicated LT-LEDS and those that have not communicated LT-LEDS but provided quantifiable information on their long-term mitigation visions, strategies and targets in their latest NDCs, the average emission reduction rate per annum between 2019 and 2030 for this group of Parties is 0.2 Gt CO_2 eq, which is equivalent to 0.6 per cent of those Parties' emissions in 2019. The average emission reduction rate per annum for this group of Parties between 2030 and 2050 is estimated at 1.1 Gt CO_2 eq, which is equivalent to 2.9 per cent of those Parties' emissions in 2019 (see figure 8).

91. If Parties were collectively to start reducing emissions in 2020 with a view to achieving their 2050 targets, and those reductions remained constant over the next three decades, the average emission reduction rate per annum between 2030 and 2050 would be 0.8 percentage points lower than currently foreseen; it is estimated at 2.1 (1.9–2.2) per cent of emissions in 2019 and equivalent to 0.8 Gt CO_2 eq/year.

[24] See table SPM.2 in IPCC. 2022. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. P Shukla, J Skea, R Slade, et al. (eds.). Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/report/ar6/wg3/.

Figure 8

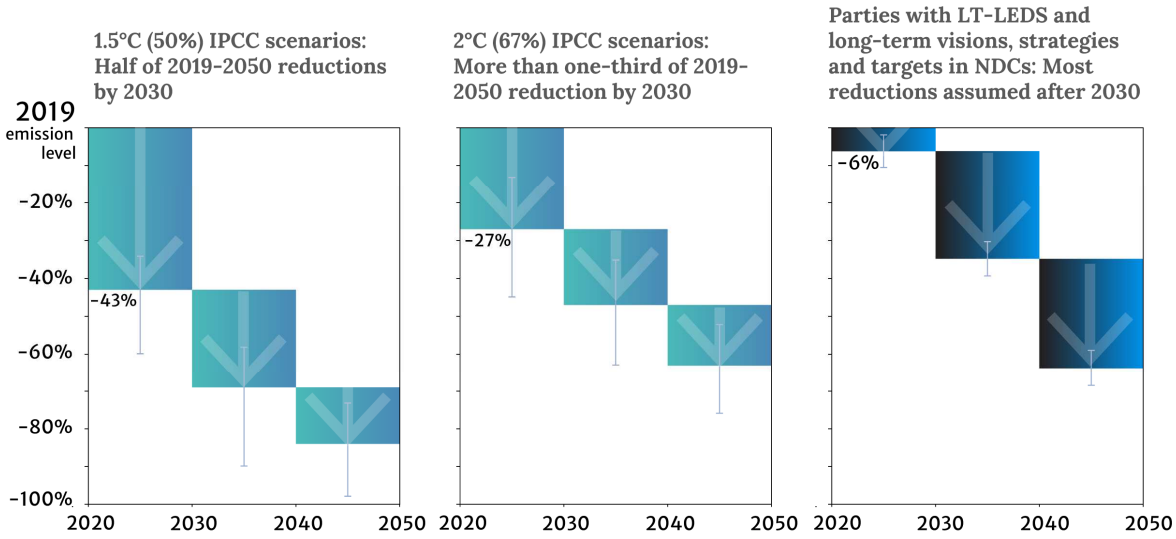
Average greenhouse gas emissions reduction rate per annum in 2019–2030 and 2030–2050 based on nationally determined contributions of Parties that communicated long-term low-emission development strategies and Parties that communicated nationally determined contributions with long-term mitigation visions, strategies and targets



92. Under the IPCC-assessed scenarios that limit warming to 1.5 °C (50 per cent chance) with no or low overshoot, greenhouse gas emissions are projected to fall from 2019 levels by 43 (34–60) per cent by 2030, which accounts for around half of reductions foreseen by 2050. In scenarios that likely limit warming to below 2 °C (with over 67 per cent chance) with the start of mitigation action at 2020, emissions are projected to decrease by 27 (14–45) per cent by 2030, which accounts for more than one third of reductions foreseen by 2050. For Parties that communicated LT-LEDS and those that have not communicated LT-LEDS but provided quantifiable information on their long-term visions, strategies and targets in their latest NDC, according to their NDCs, emissions are estimated to be 6 (2–11) per cent lower in 2030 than in 2019 (see para. 87 above), which means that it is assumed that most of the emission reductions foreseen by 2050 will occur after 2030 (see figure 9).

Figure 9

Comparison of greenhouse gas emission reductions in 2019–2030, 2030–2040 and 2040–2050 between the Intergovernmental Panel on Climate Change scenarios and the combination of communicated long-term low-emission development strategies and nationally determined contributions



Note: The shown scenarios that limit warming to 1.5 °C (50 per cent chance) with no or limited overshoot are categorized by the IPCC as "C1". For the scenarios that limit warming to likely below 2 °C, category "C3a" scenarios are shown, with onset of mitigation action by 2020.

4. Alignment of nationally determined contributions with long-term low-emission development strategies[25]

93. Some (40 per cent) LT-LEDS indicated that LT-LEDS will guide the development and ambition of the Parties' subsequent NDCs, including by adopting new policies and actions beyond their current NDCs. A few (8 per cent) mentioned that the latest NDCs are already aligned with the LT-LEDS. In addition, some (17 per cent) LT-LEDS described a scenario that requires deeper emission reductions than the current NDCs. Many (49 per cent) LT-LEDS did not provide information on how they relate to the NDCs.[26]

94. Some (27 per cent) LT-LEDS provided information on the level of midterm emissions between 2030 and the long-term target year, including indicative milestones in 2040 and carbon budgets for intermediate points in time, such as 2037 or 2040. In addition, some (19 per cent) LT-LEDS referred to the anticipated timing of the peak of the Parties' emissions ranging from 2020 to 2025, 2026, 2027 and 2030. Setting out such information in the emission pathways in more detail will guide Parties' subsequent NDCs.

D. Mitigation measures

1. Overview of mitigation options and priority areas

95. All LT-LEDS described mitigation measures to achieve their long-term mitigation goal that often concern a subset of one or more IPCC sectors. All LT-LEDS also communicated mitigation options in building, energy supply and transport, and almost all in agriculture, industry, LULUCF and waste. Figure 10 provides an overview of frequently mentioned mitigation options in priority areas communicated in more than 40 per cent of LT-LEDS (see chap. III.F.2 below for more detail on technologies).

[25] Decision 1/CMA.3, para. 35, noted the importance of aligning NDCs with LT-LEDS.

[26] A total of 34 per cent of LT-LEDS were communicated from individual EU member States that communicated NDCs jointly as the EU.

96. The contribution of Working Group III to the AR6 indicated mitigation options that cost USD 100/t CO_2 eq or less could reduce global emissions by at least half the 2019 level by 2030, noting that the relative potentials and costs that will vary across countries and in the longer term compared with in 2030.[27] Most LT-LEDS provided information on several of these mitigation options in the context of their mitigation pathways. Most frequently, LT-LEDS contained information on ecosystem restoration, afforestation and reforestation (96 per cent); reduced CH_4 emissions from solid waste (96 per cent); electric light-duty vehicles (94 per cent); solar energy (91 per cent); shift to public transportation (91 per cent); and industry energy efficiency (91 per cent) (for the full list, see figure 11).

97. The level of detail associated with each mitigation option varies, with some LT-LEDS providing detailed information, such as on policy instruments, implementation agencies and resource allocation. Parties often consider a package of policies to ensure complementarity and a sequence of policy interventions tailored to national circumstances. Moreover, a holistic perspective to capture cross-sectoral linkages of policy issues was illustrated in several LT-LEDS, for example, the combination of energy supply, transport, buildings and urban land-use policies to guide determining the optimal locations for distributed renewable energy facilities, residential buildings and public transport networks in urban areas.

98. Compared with mitigation actions for up to 2030, which are often described extensively in LT-LEDS, the description of those actions for beyond 2030 tends to be more abstract and high level, with a general indication of priority areas that are often based on modelled trajectories and an intention to explore technologies that are still in research, development and demonstration. Given the considerable uncertainty regarding the development and implementation of mitigation measures beyond 2030, LT-LEDS often described sectoral visions and priorities to guide respective policy plans over time.

99. Considering the long lifetime of infrastructure and the risk of locked-in carbon- and energy-intensive assets, some LT-LEDS highlighted that action taken during the current NDC implementation period will determine a considerable number of activities and associated emissions and removals in mid-century.

100. A linkage between mitigation options and adaptation was sometimes described in LT-LEDS. For example, in the area of water management, increasing energy efficiency of water treatment facilities, improving performance of hydroelectric plants and protecting ecosystems enhance adaptation to climate change with increased water availability. In contrast, large-scale implementation of water-intensive mitigation options such as nuclear power, electrolysis hydrogen production and certain biomass crops for BECCS could result in increased water demand. Limited water availability due to climate change may also create competition between different water needs in agriculture, drinking water, energy production and industry.

[27] See p.SPM-7 in the contribution of Working Group III to the AR6.

Figure 10

Share of mitigation options communicated in more than 40 per cent of long-term low-emission development strategies

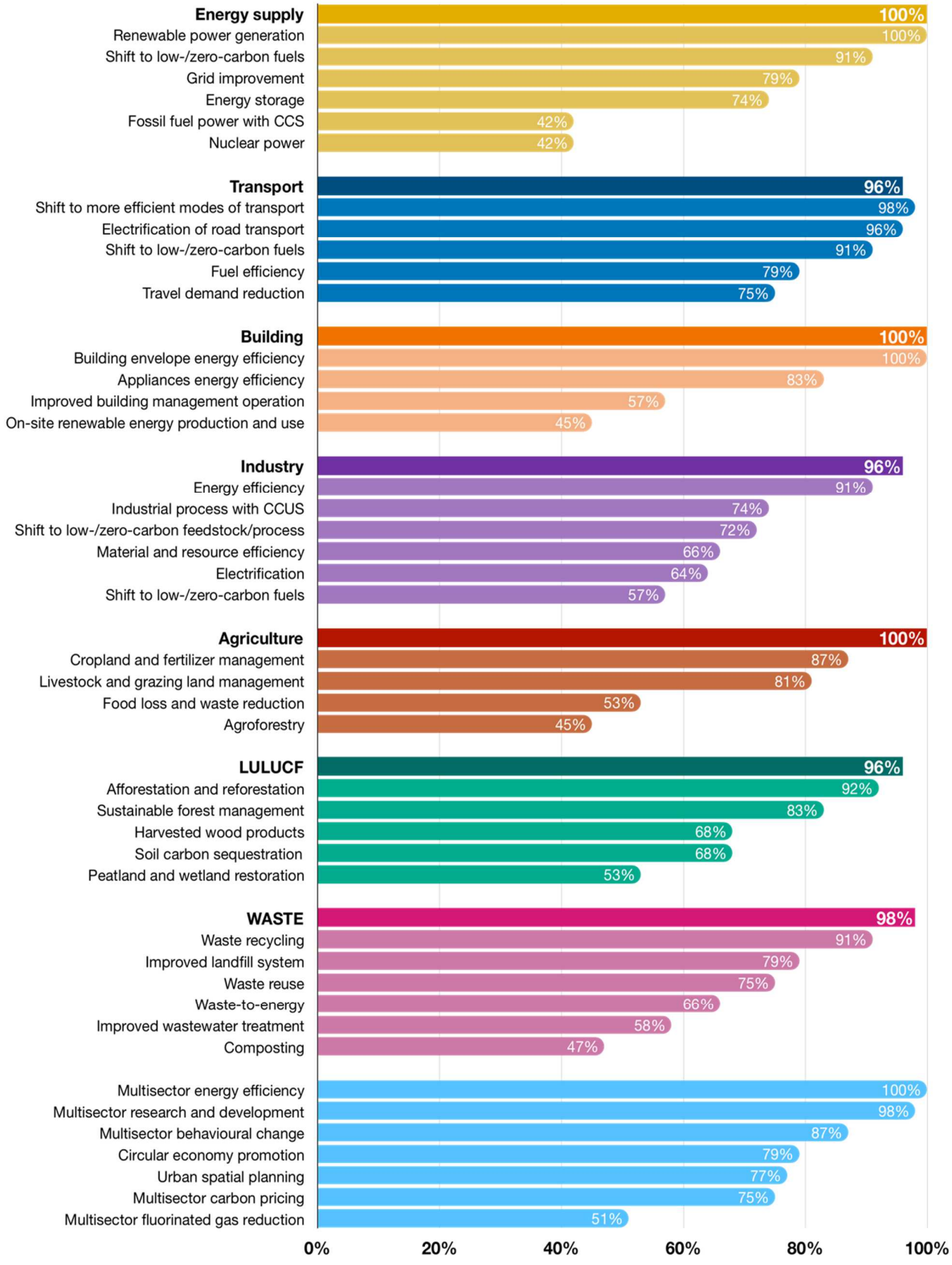
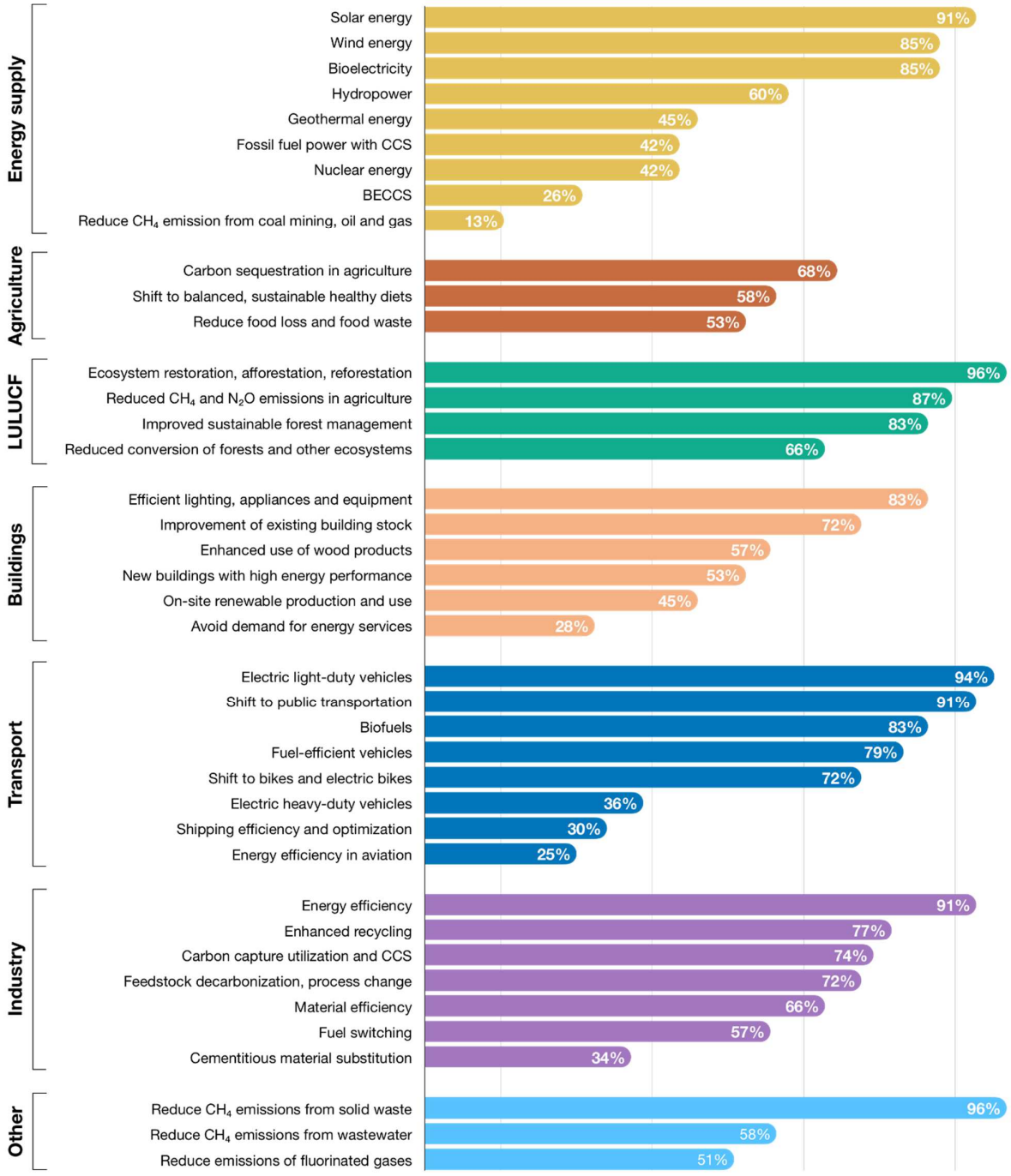


Figure 11

Share of long-term low-emission development strategies that mentioned low-cost mitigation options and could reduce global emissions by at least half of the 2019 level by 2030 according to the contribution of Working Group III to the Intergovernmental Panel on Climate Change Sixth Assessment Report



Notes: (1) Although 58 per cent of LT-LEDS mentioned "shift to balanced, sustainable healthy diets" as a mitigation option, many indicated food security as a challenge in the transition to low-emission development pathways; (2) some LT-LEDS described agriculture as one of the most vulnerable sectors to climate change impacts and hazards and therefore food production appears as one of the adaptation priority sectors in LT-LEDS.

2. Energy

101. According to the contribution of Working Group III to the AR6, energy supply and demand account for around 74 per cent of global CO_2 emission reductions at the point of net

zero emissions in modelled pathways.[28] The global use of coal, oil and gas in 2050 is projected to decline, with median values of about 85, 30 and 15 per cent, respectively, compared with in 2019 under the scenario that keeps warming to well below 2 °C ("lower than 2 °C") and 95, 60 and 45 per cent, respectively, under the scenario that keeps warming to below 1.5 °C ("1.5 °C with limited overshoot") assessed by the IPCC.[29] As such, the clean energy transition plays a crucial role in achieving the long-term temperature goal of the Paris Agreement. Ensuring access to affordable, reliable, sustainable and modern energy as referred to in SDG 7 also contributes to realizing Parties' long-term development goal.

102. All LT-LEDS indicated the plan to increase renewable energy in electricity systems. Solutions frequently reported in LT-LEDS to accommodate large shares of renewables include strengthening the electricity grid network, which was highlighted in 79 per cent of LT-LEDS, expanding energy storage in 74 per cent, and integrating energy systems across sectors in 70 per cent.

103. Multisector energy-efficiency improvements were highlighted in all LT-LEDS, often together with sector-focused measures, including energy-efficiency improvement of building in all LT-LEDS, energy-efficiency improvement of industry in 91 per cent, energy efficiency of appliances in 83 per cent and fuel efficiency of road transport in 79 per cent.

104. Several mitigation options for the energy sector frequently mentioned in LT-LEDS require long-term planning on infrastructure investment. For example, 72 per cent of LT-LEDS indicated expanding electric vehicle charging points, 91 per cent included plans for improving public transport networks, 72 per cent provided information on urban development with increased bike lanes and pedestrian zones and 45 per cent increased off-grid electricity access by generating renewable energy and constructing large-scale power plants.

105. Although there is uncertainty relating to technology development, energy prices and international trade patterns in the long term, many LT-LEDS included one or more quantitative targets on energy with a specific time frame to reflect long-term goals in near-term actions, including (see figure 12):

(a) 45 per cent referred to clean power generation targets with target years ranging from 2027 to 2035, 2040 and 2050 and referred to them in various ways, including renewable energy power, carbon-free electricity and fully decarbonized power systems. In addition, 32 per cent referred to a 100 per cent clean power generation target;

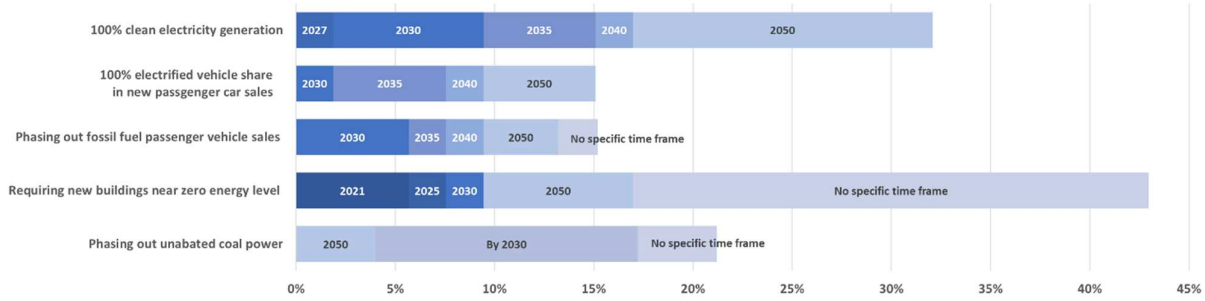
(b) 40 per cent communicated a target for new passenger vehicle sales for low- or zero-emission vehicles such as electric vehicles or new energy and clean energy-powered vehicles, including 15 per cent that communicated a target of a 100 per cent sales share ranging from 2030 to 2035, 2040 and 2050. A total of 17 per cent provided information on phasing out the sale of cars with internal combustion engines that run on diesel or gasoline. In this regard, phasing out sales of fossil-fuel passenger vehicles by 2035–2050 is considered in the SR1.5 as a mitigation option that is relevant to aligning global emissions trajectories with 1.5 °C pathways;

(c) 43 per cent highlighted that newly constructed buildings are required to be near zero energy with a timeline of 2020, 2021, 2025 or 2050. SR1.5 identified that requiring newly constructed buildings to be near zero energy by 2020 is relevant to aligning global emissions trajectories with 1.5 °C pathways;

(d) 21 per cent included a timeline for phasing out unabated coal power to produce electricity, including 13 per cent by 2030 as identified in the SR1.5, which is considered relevant to aligning global emissions trajectories with 1.5 °C pathways.

[28] See p.SPM-33 in the contribution of Working Group III to the AR6.
[29] See p.SPM-32 in the contribution of Working Group III to the AR6.

Figure 12
Example of quantitative targets on energy referred in long-term low-emission development strategies



3. Agriculture, forestry and other land use

106. Almost all (96 per cent) LT-LEDS mentioned the clear role of AFOLU in LT-LEDS in both reducing emissions and enhancing natural carbon sinks, and also noted the importance of their resilience and sustainability.

107. There are significant uncertainties in the estimates of anthropogenic emissions by sources and removals by sinks in the AFOLU sector, as well as in future projections. However, about half of LT-LEDS attempted to quantify the expected contribution from the AFOLU sector to emission reductions in 2050, although with diverse methods and sometimes accompanied with large potential ranges reflecting different outcomes by different available models.

108. In the light of the increasing frequency and impact of extreme weather events, some (30 per cent) LT-LEDS communicated specific concerns related to carbon sinks and carbon stocks becoming unstable due to climate change or other long-term degrading effects. These concerns are especially important in ecosystems with limited adaptive capacity, such as monocultures, dry or mountain ecosystems, or already degraded land.

109. With regard to mitigation potential for agriculture, 79 per cent of LT-LEDS referred to improvements in grazing land and livestock management; 85 per cent to improved cropland and fertilizer management; 77 per cent to targeted research and development, innovation, technology and rural extension services as important preconditions for effective interventions in the agriculture sector; and 43 per cent to the potential of agroforestry.

110. Addressing emissions from forests and land-use change and enhancing removals in forests simultaneously was covered in 79 per cent of LT-LEDS, including activities such as increasing the sustainable management of forests, addressing deforestation or restoring degraded forests. In this context, 30 per cent of LT-LEDS underlined the long-term role of implementing REDD+ activities. In addition, 53 per cent of LT-LEDS considered significant potential in the restoration of peatlands and wetlands, including 21 per cent that made explicit reference to blue carbon.

111. Almost all LT-LEDS included activities to enhance sinks and reservoirs of GHGs, including in forests and other ecosystems. In total, almost all (91 per cent) LT-LEDS referred to a role for increased forest area by afforestation and reforestation activities to achieve long-term low-emission targets. In addition, 68 per cent of LT-LEDS highlighted the potential of increasing soil carbon sequestration in agricultural lands, including cropland and grassland. Another option is increasing carbon storage in the harvested wood products pool, for example by prioritizing uses of wood that have a longer lifespan and high substitution potential, which was mentioned in 68 per cent of LT-LEDs.

112. Reducing food loss and waste at the different stages of production and consumption was identified as an activity to reduce emissions in 51 per cent of LT-LEDS, for example by reducing food waste in the retail sector, exploring potential uses for recovered organic waste, adapting consumption patterns towards more local and seasonal products.

4. Carbon dioxide removal

113. The contribution of Working Group III to the AR6 identified several AFOLU mitigation options as the only currently widely practised CO_2 removal options, including afforestation, more sustainable forest management, peatland and wetland restoration, agroforestry, and blue carbon management; however, their removal potential is limited owing to competition for other land uses. It further stated that removing CO_2 to counterbalance hard-to-abate residual emissions is unavoidable if trying to achieve net zero CO_2 or other GHG emissions. In this regard, Parties reported non-conventional CO_2 removal options. For example, 27 per cent of LT-LEDS mentioned BECCS as necessary to limit temperature increase but not immediately deployable, and 13 per cent mentioned DACCS as technology that may be used in the future should significant cost reduction be needed (see chap. III.F.2 below for more information on carbon capture technologies).

5. Circular economy, resource efficiency and waste management

114. According to the contribution of Working Group III to the AR6, the circular economy concept is an increasingly important mitigation approach that can help deliver human well-being by minimizing the waste of energy and resources.[30]

115. Most (81 per cent) LT-LEDS mentioned the circular economy as an objective or guiding principle for their long-term low-emission development, particularly in the context of mitigation. Almost all LT-LEDS indicated specific elements described under the circular economy concept, including resource and material efficiency of industry (66 per cent), waste reuse (75 per cent) and waste recycling (91 per cent).

116. With regard to the concept of a circular economy, Parties aim to reduce demand for new raw materials, energy inputs and water; minimize waste; and conserve the ecosystem through the efficient use of resources, including through product reuse, recycling and sharing. The circular economy provides a cross-sectoral life cycle perspective, and Parties reported priority sectors as including construction, food, forestry and transport.

117. Shifting from a linear economy to a circular economy entails changes in production processes and consumption patterns in favour of products designed to be durable, repairable, recyclable and renewable. In the context of renewable products, a few LT-LEDS underlined the concept of a bioeconomy where wood is promoted as both a raw material and a final product as a way to sustainably regenerate a natural system.

118. The policy effort referred to most frequently in LT-LEDS was a national road map and strategy for a circular economy, and other measures included improving the system and infrastructure for waste collection, separation and recycling; tightening industry standards and targets for using recycled materials; promoting eco-design with a focus on reuse, durability, recyclability, recycled material content and reparability; raising consumer awareness; and using empty built public spaces and multifunctional and shared buildings to reduce built area.

E. Adaptation

119. Almost all (98 per cent) LT-LEDS included adaptation-related information. Most (72 per cent) LT-LEDS incorporated a chapter or component on adaptation information. Parties provided specific information on climate change hazards and risks; vulnerability and impacts on priority sectors; adaptation-related policies, strategies, frameworks and plans; planned or implemented sectoral adaptation actions; synergies between adaptation and mitigation; and quantified adaptation targets for monitoring and evaluating adaptation progress.

[30] The essence of a circular economy is shifting away from linear ‘make and dispose’ economic models to those that emphasize product longevity, reuse, refurbishment, recycling and material efficiency, thereby enabling more circular material systems, which reduce embodied energy and emissions. See TS.12 in the contribution of Working Group III to the AR6.

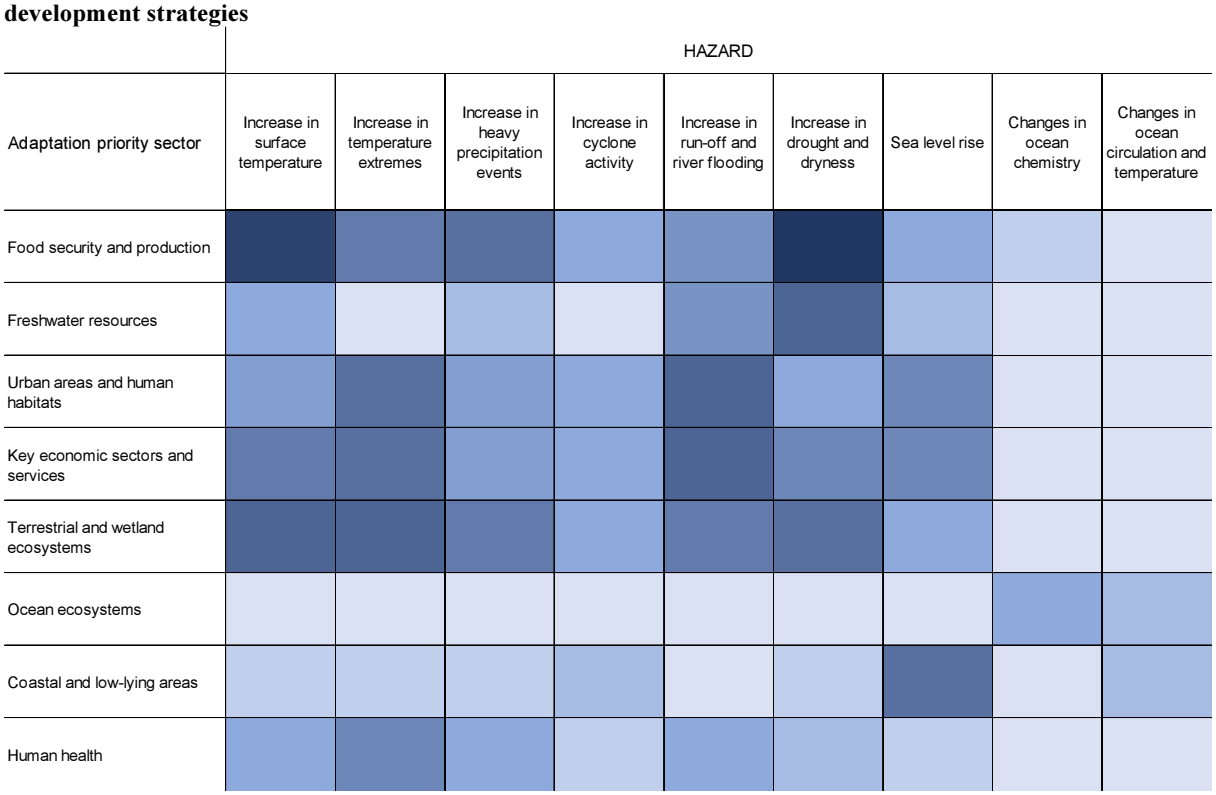
1. Risks, vulnerability and impacts

120. Most (79 per cent) LT-LEDS provided information on key climatic changes, in particular increases in mean air temperature, precipitation changes and sea level rise. These were identified as triggering hazards and climate change impacts. The hazards include increases in frequency and intensity of drought, fluvial and coastal flooding, storms and tropical cyclones, heatwaves, extreme temperatures, heavy rainfall events, landslides, fires, ocean acidification and ocean temperature, as well as decreases in snow cover and sea ice. Agriculture, livestock and fisheries; water resources; critical infrastructure; urban areas and settlements; terrestrial and coastal biodiversity and ecosystems; human health; and tourism were shown in LT-LEDS to be the most vulnerable sectors to climate change impacts and hazards.

121. Figure 13 provides an overview of the main climate change hazards identified, following the IPCC classification,[31] and impacts related to adaptation priority sectors in LT-LEDS. For instance, figure 13 shows that increases in surface temperature and drought can affect food production and nutrition (e.g. crop productivity, composition of pasture), and an increase in extreme temperatures can adversely affect human health.

122. Geographic location, dependence on climate-sensitive sectors, pressures on natural resources due to economic and population growth, and lower levels of development and adaptive capacity were identified as the main factors of vulnerability. Women, children and youth, the elderly, indigenous people and people with disabilities are particularly vulnerable to climate change.

Figure 13
Linkages between climate change hazards and adaptation priority sectors in long-term low-emission development strategies



Note: The shading reflects how frequently linkages were identified by Parties: the darker the shading, the more frequently linkages were identified.

[31] IPCC. 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. H Pörtner, D Roberts, M Tignor, et al. (eds.). Cambridge, United Kingdom of Great Britain and Northern Ireland: Cambridge University Press. Available at https://www.ipcc.ch/report/ar6/wg2/.

2. Adaptation-related policies and frameworks

123. Almost all (92 per cent) LT-LEDS provided an overview of national adaptation and resilience policies and strategies of developed countries, together with NAPs of developing countries. National adaptation and resilience policies and strategies of developed countries typically focused on reviewing risks and vulnerabilities, including adaptation actions, driving innovation and investments, strengthening cooperation among multiple actors, tracking adaptation progress and supporting learning.

124. NAPs served as the main policy framework to improve adaptation and resilience in key sectors at the national, subnational and sectoral level. Some LT-LEDS mentioned that NAPs were in the process of development, while others had already developed NAPs and/or were preparing for the measurement, reporting and verification process. A few LT-LEDS described how NAPs enhanced linkages or synergies with LT-LEDS.

125. Some (38 per cent) LT-LEDS were linked to disaster risk reduction policies, national development plans and national mitigation and adaptation plans (particularly NDCs and NAPs).

126. In addition to national adaptation or resilience policies and measures, some (25 per cent) LT-LEDS described subnational actions or targets to undertake in order to contribute to national adaptation efforts. Examples include preparing sectoral adaptation plans at the local and subnational level, assessing local vulnerability, advancing monitoring and evaluation, integrating mitigation and adaptation actions, raising public awareness of climate change, improving local capacity for adaptation and implementing nature-based solutions.

127. As a cross-cutting issue, some (38 per cent) LT-LEDS stressed the importance of incorporating a just transition into their long-term adaptation plans and strategies. It was highlighted that a goal within the adaptation process should be to reduce existing inequalities. As such, just transition was typically viewed in the context of equity, which focused on integrating gender and intergenerational approaches into adaptation measures, as well as inclusive public and stakeholder participation in the policymaking processes. A few LT-LEDS showed the integration of the gender approach into key adaptation sectors. Similarly, the engagement of indigenous people and their contribution of traditional knowledge to the development and implementation of adaptation measures were viewed as crucial for achieving just transition. In addition, a few LT-LEDS reflected on transformation, which should promote the incorporation of a human rights based approach and ensure that adaptation can benefit the most vulnerable groups.

3. Adaptation measures

128. Adaptation priority sectors in LT-LEDS were typically aligned with priority sectors in NDCs (see figure 14). Terrestrial and wetland ecosystems (75 per cent of LT-LEDS), together with food security and production (74 per cent), which includes agriculture, livestock and fisheries, were the highest priority for adaptation, followed by key economic sectors and services (64 per cent), urban areas and human habitats (58 per cent), human health (45 per cent), freshwater resources (45 per cent), coastal and low-lying areas (40 per cent) and ocean ecosystems (19 per cent). Many (45 per cent) LT-LEDS emphasized the importance of designing and implementing nature-based solutions in building resilience and adaptation in priority sectors.

129. Adaptation measures in the biodiversity and ecosystem sector (58 per cent of LT-LEDS) were aimed at creating natural protected areas, landscape-scale restoration of native biodiversity, ecological connectivity, control of invasive species, sustainable management of urban biodiversity and wetlands, conservation of species that provide benefits for both adaptation and mitigation, recovery plans for threatened species, promotion of nature-based solutions, capacity-building for sectoral adaptation measures and financial mechanisms. Many (55 per cent) LT-LEDS documented adaptation efforts in the forest sector, for example, increasing the diversity and density of climate-tolerant tree species; controlling invasive species; sustainable forest management, reforestation and afforestation; conservation of grasslands; forest fire prevention; integration of traditional and local knowledge; innovation; and mainstreaming adaptation into forestry policies.

130. Measures for adapting agriculture (70 per cent of LT-LEDS) included climate-smart agriculture, agroecology and agroforestry that provide synergies with mitigation; climate-resilient crop varieties (including improved productivity and quality); supplying regional and seasonal climate-friendly agricultural products; controlling invasive species and plant diseases; ensuring sustainable and integrated soil management; and implementing nature-based solutions. Other measures included the development of sectoral adaptation plans, research and innovation, financial mechanisms and insurances, integration of traditional and local knowledge, knowledge-sharing, and awareness-raising. Enhancing adaptation in fisheries and aquaculture (30 per cent) involved capacity-building in climate-smart fisheries, public–private partnerships, mainstreaming adaptation into existing strategies, promoting nature-based solutions, research, and new financial mechanisms, while measures in the livestock sector (26 per cent) included climate-smart farming, access to climate information, sustainable and resilient technologies, early warning systems for disease control in farming, climate-resilient breeds and access to financial support to strengthen food security.

131. Many (64 per cent) LT-LEDS described planned and implemented adaptation efforts in key economic sectors and services, particularly energy, infrastructure, tourism and transportation. In the energy sector (49 per cent) measures encompassed climate-resilient energy systems, decentralization and diversification of renewable energy sources, climate-resilient design and installation standards, adjustments to the imbalances between energy supply and demand, and integration of climate risks and adaptation into energy policies. Adaptation efforts in the infrastructure sector (38 per cent) incorporated the development of climate change criteria for new infrastructure, climate risk assessments and promotion of nature-based solutions. Adapting the tourism sector (32 per cent) included diversification and development of climate-friendly tourism practices (eco-, green- and scientific tourism), application of energy- and water-saving technologies, public–private partnerships for sustainable and resilient tourism development with local and indigenous communities, tourist tax systems for supporting adaptation, monitoring of highly vulnerable touristic areas, mainstreaming climate risks and adaptation into existing policies, and awareness-raising. Adaptation efforts in transportation (32 per cent) focused on mainstreaming climate risks and adaptation into existing plans, implementing nature-based solutions and knowledge-sharing. A few LT-LEDS also mentioned industry and mining (15 per cent) as having undergone an adaptation process, for example through mainstreaming adaptation into existing plans, implementing nature-based solutions and increasing awareness of synergies between mitigation and adaptation.

132. In many (58 per cent) LT-LEDS, urban areas, settlements and the housing sector were identified as an adaptation priority. Adaptation responses in urban areas and settlements (47 per cent) included regulations for climate-adapted spatial planning, implementation of nature-based solutions including replacement of grey infrastructure with green, climate-proof cities, new urban design and standards that consider climate risks, upgrading informal settlements and protecting highly vulnerable settlements, early warning systems and local evacuation plans, mainstreaming adaptation into existing strategies, and awareness-raising. Measures in the housing sector (36 per cent) included new climate-resilient design and building codes, climate-proofing and refurbishment of buildings (including elevation and relocation), mainstreaming climate risks and adaptation into construction plans, and implementing nature-based solutions.

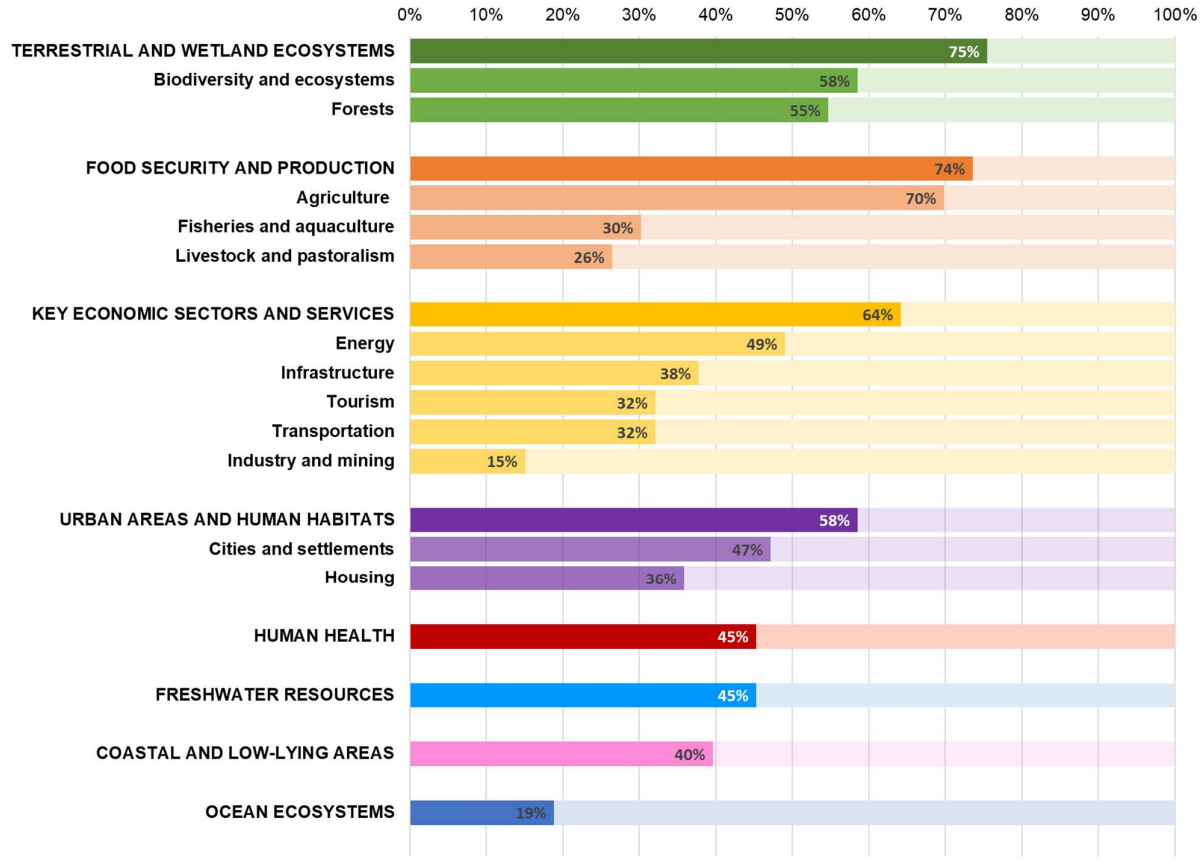
133. Human health was identified as an adaptation priority in many (45 per cent) LT-LEDS. Adaptation measures included developing a climate-resilient public health system and infrastructure, early warning systems for diseases and extreme weather events, research and innovation, training health-care professionals, and mainstreaming adaptation into health policies.

134. Many (45 per cent) LT-LEDS included measures for adapting freshwater resources, particularly protecting and monitoring the quality, availability and efficiency of the water supply; developing climate-resilient and integrated water management and infrastructure; implementing nature-based solutions; restoring watersheds; adopting conservation-based irrigation systems; desalinization; mainstreaming climate risks and adaptation into existing water strategies.

135. In some (40 per cent) LT-LEDS, Parties highlighted measures for enhancing the resilience of coastal and low-lying areas, for instance, nature-based solutions and grey infrastructure; conservation and restoration of mangroves, dunes and wetlands; new regulations and standards for coastal defences; integrated coastal zone management; capacity-building in climate-resilient coastal management; early-warning systems and evacuation plans; and financial mechanisms.

136. Measures for adapting ocean ecosystems (19 per cent) focused on protecting and restoring blue carbon ecosystems (mangroves, seagrass beds) and coral reefs, creating marine-protected areas, promoting synergies between mitigation and adaptation, providing education, and awareness-raising.

Figure 14
Share of adaptation priority sectors identified in long-term low-emission development strategies



4. Synergies between adaptation and mitigation

137. Many (62 per cent) LT-LEDS provided information on synergies between adaptation and mitigation actions. These synergies commonly emphasized that their adaptation and resilience efforts must be jointly undertaken with mitigation efforts.

138. In particular, synergies in the forestry, biodiversity and ecosystem sector were highlighted as important. Examples of potential for adaptation and emission reduction include afforestation and reforestation with local native and climate-resilient tree species; conservation and restoration of wetlands, grasslands and peatland; sustainable management of soils, seagrasses and seaweeds; rehabilitation and restoration of rivers and floodplains; implementation of nature-based solutions and urban ecosystems; and establishment of natural and marine protected areas.

139. In terms of synergies in the agriculture, fishery and livestock sectors, Parties described climate-smart agricultural technologies; integrated plant management and improvement of the sink capacity of the soil; increased productivity and diversity of species in agroforestry;

expanded production and improved productivity of home gardening; mentioned traditional extensive livestock farming that contributes to cleaning forests, reducing fire risk, and strengthening biodiversity and ecosystems; improved use of mulching and composting techniques; and described climate-friendly fishing vessels powered by renewable energy.

140. In the energy sector, diversified renewable energy generation, introduction of self-sustained and distributed renewable energy, and design and construction standards for energy facilities (considering climate change impacts and risks) were mentioned in LT-LEDS. Developing and implementing technologies to streamline and conserve water use and increasing awareness of water conservation can reduce emissions while simultaneously improving adaptation.

141. In the health sector, synergies include constructing new energy-efficient buildings and retrofitting existing buildings to improve health by reducing respiratory and cardiovascular conditions, rheumatism and allergies, particularly in vulnerable groups, while synergies in transportation relate to the health benefits gained from reduced pollution and lower concentration of emissions. Promoting coastal conservation and using green infrastructure to enhance resilience, adaptation and carbon storage were emphasized in the tourism sector. Similarly, promoting urban farms and compact urban areas (minimizing urban sprawl), as well as developing a circular economy, can create synergies between adaptation and mitigation and lead towards a low-emission and climate-resilient society.

5. Quantified adaptation targets

142. Some (19 per cent) LT-LEDS included quantified targets covering all adaptation priority sectors (see the table below). Most (81 per cent) LT-LEDS presented sectoral adaptation actions without quantifiable information that would allow monitoring of adaptation progress.

Examples of quantified targets in adaptation priority sectors communicated in some long-term low-emission development strategies

Priority sector	*Quantified target*
Agriculture	70 per cent of agricultural producers have access to agroclimatic information by 2050
Biodiversity	50 per cent of nature-based solutions are used as adaptation measures in priority sectors by 2030
Coastal areas	60 per cent of the coastline is protected by nature-based solutions by 2050
Energy	100 per cent of municipalities and regions have implemented disaster risk reduction strategies for the energy sector by 2050
Fishery	100 per cent of fish stocks are maintained at a sustainable level by 2050
Forestry	50 per cent of forest species are adapted to climate change by 2050
Health	100 per cent of the national territory has implemented an early warning system in the public health system by 2050
Infrastructure	50 per cent of critical infrastructure is protected using nature-based solutions by 2050
Livestock	80 per cent of cattle farming has improved adaptive capacity against extreme weather events by 2050
Ocean ecosystem	30 per cent of exclusive economic zone is established as a marine protected area by 2025
Settlements	100 per cent of municipalities have reduced the vulnerability of settlements located in high-risk areas by 2050
Tourism	50 per cent of the most vulnerable touristic destinations have mainstreamed adaptation in their plans by 2030
Transportation	20 per cent of transportation infrastructure has implemented nature-based solutions against climate change impacts by 2050
Water resources	90 per cent of the population has access to a reliable water supply during extreme weather events by 2030

F. Finance, technology development and transfer, capacity-building and international cooperation

1. Finance

143. Most (85 per cent) LT-LEDS referred to financial needs for implementing LT-LEDS, with 26 per cent providing costed needs, 26 per cent describing finance needs qualitatively and 33 per cent providing general statements on needs. Some (12 per cent) LT-LEDS provided financial needs based on scenarios with existing measures as well as with additional measures to achieve net zero emissions by 2050. Climate finance needs for mitigation expressed in LT-LEDS were in the energy, forestry, industry, land use, and transportation sectors, while adaptation finance is needed for activities related to agriculture, coastal protection, disaster risk management, disaster risk reduction, and ecosystem and biodiversity. The submissions identified funding sources for implementing LT-LEDS, such as domestic finance, international support and private finance. Many (53 per cent) either acknowledged or identified domestic resources, 35 per cent of the submissions noted a reliance on international support to implement their LT-LEDS and 58 per cent acknowledged the role of the private sector in implementing long-term strategies.

144. Some (38 per cent) LT-LEDS specified their commitment to supporting climate action in the context of investments in or support to developing countries. In addition, 27 per cent of submissions described the provision of international support. Types of support to developing countries referenced in LT-LEDS include a broad range of activities, channels and instruments, including establishing bilateral and regional cooperation, promoting green investment through strategic sector cooperation, allocating grants and loans for capacity-building, and sponsoring research and development of innovative technologies for mitigation and adaptation.

145. Many (55 per cent) LT-LEDS provided information on efforts taken by the respective government to increase finance flows through economic policy measures, financing mechanisms or financial instruments. Another 42 per cent of the submissions stated that the countries either have fiscal policies in place or plan to implement them. Taxes, levies, fiscal incentives and carbon pricing mechanisms are among the most commonly referenced fiscal policy tools for spurring low-carbon investments. Other types of economic or regulatory policies and measures discussed in the strategies include green tariff systems and emission pricing based on the 'polluter pays' principle. Some strategies also indicated specific funds, dedicated programmes and incentives for green investments, as well as national action plans to regulate emissions.

146. Some (32 per cent) LT-LEDS provided information on instruments and national mechanisms that can support the implementation of the LT-LEDS. In addition, 19 per cent of LT-LEDS provided general information on the specific funds for priority sectors such as agriculture, energy and transport that have been established, are in the process of being established or whose establishment is planned by their respective governments. Loans, guarantees, grants and the establishment of a green bond market that issues green sovereign bonds were some of the financial instruments discussed as a part of broader efforts to transition to low-emission and climate-resilient development.

147. Many (54 per cent) LT-LEDS stated the importance of making the financial flows consistent with a pathway towards low-emission and climate-resilient development, of which 21 per cent were from developing countries. Some provided information on redirecting financial flows consistent with a pathway towards low-emission and climate-resilient development by developing national financial strategies such as attracting green foreign direct investment, establishing green taxonomies to facilitate redirecting financial flows, and developing climate finance strategies and road maps. In addition, 10 per cent of LT-LEDS plan to implement mandatory climate-related financial disclosures in line with the Task Force on Climate-related Financial Disclosures.

2. Technology development and transfer

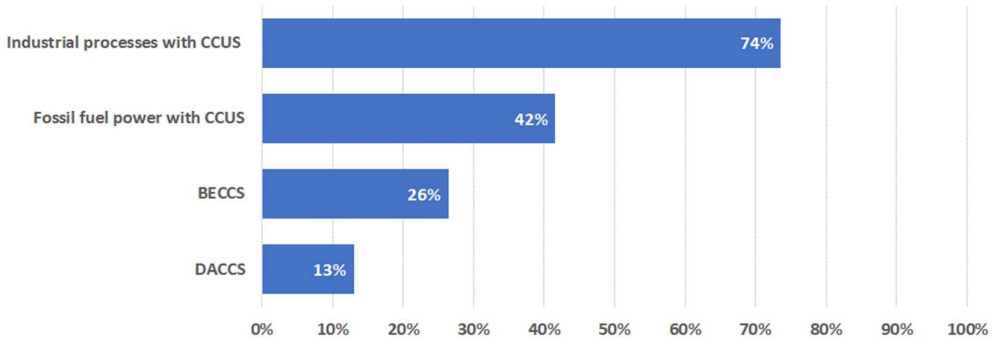
148. Almost all (98 per cent) LT-LEDS highlighted that technologies and innovation are fundamental to addressing climate change and the economic growth of countries as they help

to create jobs, increase competitiveness, support sustainable development and enhance living standards. The contribution of Working Group III states that, in driving the rapid deployment of competitive technologies, a well-designed mix of policies may serve to further reduce costs, including of public research and development, demonstration and pilot projects, and demand-pull policies, which create incentives and market opportunities.[32]

149. Almost all (98 per cent) LT-LEDS communicated innovation, research and development of technologies as a key transition and mitigation enabler. Parties aim to achieve substantial decarbonization with currently available and proven technologies such as renewable energy technologies for electricity and heat production, air conditioning and energy-efficiency technologies, but Parties also highlighted challenging areas for emission abatement because key technologies are not yet widely commercialized, such as flexible power systems to accommodate variable renewable energy generation; long-distance transport, and industrial processes that require an increased policy focus; strong governmental support of research and development; and the availability of finance to secure investment into climate technologies and supporting infrastructure.

150. Multiple applications of carbon capture technology were communicated by Parties, including fossil-fuel power with CCUS, CCUS in industry production and processes, BECCS and DACCS (see figure 15). Several actions to use CCUS were reported in LT-LEDS, including reducing cost, developing suitable sites and improving the environment for its commercialization while formulating long-term road maps. Areas of research and development include CO_2 separation and capture technology; storage technology; elaboration and automation of monitoring technology; and cost reduction for drilling, storage and monitoring (see chap. III.D.4 above about carbon dioxide removal).

Figure 15
Share of carbon capture technology applications reported in long-term low-emission development strategies



151. The contribution of Working Group III to the AR6 states that unit costs of several low-emission technologies have fallen continuously since 2010, including solar energy, onshore and offshore wind energy, and batteries, and that electricity systems powered predominantly by renewables are becoming increasingly viable.[33] Owing to the key role of renewable energy, most (79 per cent) LT-LEDS contained information on electricity grid improvement in terms of grid capacity, flexibility and resilience with a view to supplying energy in a reliable manner and at an affordable cost. Among the low- or zero-carbon fuels mentioned in almost all (91 per cent) LT-LEDS, most commonly reported fuels are hydrogen (87 per cent) with some referring to green hydrogen, biofuels (83 per cent) and synthetic fuel (58 per cent) that will increasingly be used wherever it is not feasible to use electricity, especially in aviation and shipping.

152. Several transport technologies were identified that provide opportunities to reduce GHG emissions, save money for businesses and households, improve environmental quality and health in communities, and provide more choices for moving people and goods. Key

[32] See pp.SPM-12 and SPM-60 in the contribution of Working Group III to the AR6.
[33] See pp.SPM-12 and SPM-36 in the contribution of Working Group III to the AR6.

technologies required include deploying vehicles that run on clean electricity and shifting to low- or zero-carbon biofuels, synthetic fuels and hydrogen in applications such as long-distance shipping and aviation. Shifting to low- or zero-carbon fuels was the most frequently mentioned measure in shipping and aviation, reported for each sector in 53 per cent of LT-LEDS.

153. Raising public awareness of available and affordable climate technologies was considered an effective tool for implementing climate technologies on both supply and demand sides.

154. The lack of energy security was seen as hampering decarbonization efforts in some LT-LEDS. The indicator of imported energy dependence was above 80 per cent in some Parties because local energy sources are limited. Therefore, promoting the use of available renewable technologies and of long-term research and development was proposed to significantly decrease the dependency gap in these countries, avoiding their import of fossil energy resources.

155. Many LT-LEDS reported the strengthening of the Party's international cooperation to accelerate the deployment and application of cutting-edge, critical and disruptive technologies, including through joint planning and the mainstreaming of technological innovation. The joint development of sustainable energy consumption technologies, including energy-saving and energy-efficiency technologies, delivers low-cost emission reduction measures cost and significant synergistic benefits in the medium and long term.

156. Other areas of international cooperation considered key to accelerating technology deployment in LT-LEDS include standardization and codification in electricity systems, vehicles, buildings and energy efficiency. Partnerships for advanced technology research and development were frequently mentioned as an effective way to widely deploy new inventions. Strong partnerships were also highlighted in the advancement of building energy codes and appliance standards to ensure that building envelopes, electric appliances and other equipment become increasingly efficient over time.

3. Capacity-building

157. In general, the LT-LEDS considered capacity-building as a cross-cutting issue that is the overarching enabler of adaptation and mitigation actions and commitments. In addition, the LT-LEDS highlighted the importance of capacity-building for facilitating technology development, access to climate finance, public engagement, and transparent communication of information. Overall, LT-LEDS deemed capacity-building crucial to the implementation of the LT-LEDS operational strategy.

158. A total of 57 per cent of LT-LEDS emphasized the importance of adaptive capacity for managing the transition to a decarbonized, climate-resilient future in the long term, through enhancing the social and ecological capacity of systems to absorb stresses and maintain functions in face of climate change, and to reorganize social activities and human behaviour in preparation for the future impacts of climate change.

159. Furthermore, a majority of LT-LEDS highlighted the importance of providing capacity-building, including education and training, to all stakeholders in order to raise awareness for a climate-conscious society and equip the population with the skills and knowledge needed for climate action (see chap. III.G.2 below for a more detailed analysis of the ACE elements). Ultimately, by taking an integrated approach to capacity development and providing capacity-building support at all levels, all sectors can be mobilized towards the pathway to net zero emissions, and all stakeholders can be supported in the workforce transition towards a climate-resilient economy.

160. In total, 42 per cent of LT-LEDS referenced international cooperation as helping to achieve their LT-LEDS. Specifically, the submissions highlighted that international cooperation is crucial for fulfilling a range of identified capacity needs and gaps, including technical, infrastructural, financial, human and institutional needs and gaps.

161. Specific mention was made of different forms of international cooperation, such as South–South, North–South, and triangular cooperation, to facilitate the sharing of best practices and the transfer of expertise from developed to developing countries. For select

Parties, capacity-building partnerships through regional institutions and groupings are considered especially important for aligning national and regional plans and actions.

4. Voluntary cooperation

162. Some (42 per cent) LT-LEDS mentioned an intention to use voluntary cooperation, including the general use of voluntary cooperation under Article 6 of the Paris Agreement; use of cooperative approaches under Article 6, paragraph 2; use of the mechanism under Article 6, paragraph 4; and use of non-market approaches under Article 6, paragraph 8. A few (9 per cent) LT-LEDS indicated qualitative limits on their use of voluntary cooperation, including environmental integrity, transparency and avoidance of double counting of emission reductions. A few LT-LEDS mentioned the possibility of using offsetting to achieve the long-term net zero emissions goal.

G. Planning and implementation

1. Stakeholder engagement

163. When adopting the Paris Agreement, COP 21 encouraged Parties to work closely with non-Party stakeholders to catalyse efforts to strengthen mitigation and adaptation action and decided that high-level champions should be appointed to facilitate the successful execution of existing efforts and the scaling up and introduction of new or strengthened voluntary efforts, initiatives and coalitions.[34] Marrakech Partnership for Global Climate Action was later launched by the champions as a framework to strengthen collaboration between Parties and non-Party stakeholders, leading to Climate Action Pathways, Race to Zero and Race to Resilience.[35]

164. Almost all (94 per cent) LT-LEDS highlighted that effective stakeholder engagement plays an important role in Parties' planning and implementation, as successful economic transformation requires collective commitments to achieving the long-term goal by stakeholders. In addition, most (75 per cent) LT-LEDS referred to stakeholder engagement during the preparation of LT-LEDS and most (90 per cent) LT-LEDS referred to stakeholder engagement during the implementation of LT-LEDS.

(a) Objective and benefit of stakeholder engagement

165. In their LT-LEDS, Parties highlighted engagement with various stakeholder groups in the LT-LEDS preparation process and implementation plan, including subnational governments in all LT-LEDS, civil society actors in 87 per cent, the private sector in 81 per cent, the scientific community including academia and research institutes in 77 per cent, industries and financial partners in 47 per cent, youth in 47 per cent, women in 40 per cent, workers in 36 per cent, trade unions in 26 per cent and indigenous communities in 28 per cent.

166. Objectives and benefits of stakeholder engagement mentioned in LT-LEDS include strengthening shared leadership, ownership and high acceptance in 51 per cent; increasing the quality, transparency, acceptance and clarity of decisions in 49 per cent; building trust and enhancing connections with the political system and public administration in 34 per cent; defining priorities and developing strategies tailored to national circumstances in 34 per cent; raising awareness on climate change in 31 per cent; identifying barriers, solutions and support needed in the short, medium and long term in 28 per cent; collecting data and information that might not have been publicly available, thus enabling better design of policies and targets, in 26 per cent; establishing a common and shared frame of reference through a bottom-up approach in 26 per cent; promoting understanding of different views in 25 per cent; developing innovative ideas in 17 per cent; and partnering with financial and international organizations to secure appropriate means of implementation in 9 per cent.

[34] Decision 1/CP.21, paras. 118 and 121.

[35] See https://unfccc.int/climate-action/marrakech-partnership/reporting-and-tracking/climate_action_pathways; https://racetozero.unfccc.int/join-the-race-to-resilience; and https://climatechampions.unfccc.int/join-the-race/.

(b) Engagement mode

167. Modes of stakeholder engagement described in LT-LEDS include a consultation process under ad hoc political bodies that provided oversight and technical guidance; parliamentary hearings; citizens' assemblies and forums; bilateral meetings between stakeholders and public authorities; cross-cutting and multisectoral consultations and dialogues at the national, subnational and local level; expert working groups and workshops; brainstorming sessions; capacity-building, awareness-raising and education programmes and campaigns; modelling exercises; various information exchange platforms, including formal large-scale public consultations and non-formal conversation spaces; online surveys and consultation portals; stakeholder participation to monitor processes in a transparent manner; publicly available written comments on LT-LEDS at different stages of their preparation; and dialogue with vulnerable sectors and populations affected by the socioeconomic transition to a low-emission economy, building on the experience of LT-LEDS preparation.

(c) Subnational government

168. All LT-LEDS underlined the role of subnational governments, including cities, municipalities and states, in realizing a transformation to achieve their long-term goals because they often have jurisdiction over a wide range of policy areas including local economic development; spatial and urban planning; housing; transport infrastructure development; waste collection and management; agriculture; local resource, environment and biodiversity management; and tourism. In addition, their proximity to citizens and local business was mentioned as a key asset in developing solutions tailored to local circumstances. Key elements for successful implementation and raising ambition at the subnational level described in LT-LEDS include enabling institutional capacities and robust support from the national government, such as adequate legal basis, resources and access to information on new national regulations and policies, as well as participation in their design from an early stage. A few (2 per cent) LT-LEDS consisted of regional instead of a national LT-LEDS and a few (2 per cent) included information on regional LT-LEDS together with a national LT-LEDS.

2. Action for Climate Empowerment

169. ACE denotes work under Article 12 of the Paris Agreement. The objective of ACE is to empower all members of society to engage in climate action through climate education and public awareness, training, public participation, public access to information and international cooperation on the ACE elements.

170. Almost all (98 per cent) LT-LEDS provided information on using one or more elements of ACE to ensure the effective implementation of mitigation and adaptation measures and acknowledged those elements as indispensable tools to mobilize all sectors of society towards achieving the long-term goals. Parties recognized that the transition to a low-emission economy and society could only be achieved with a collective long-term vision in which all members of society, including children and youth, are educated and empowered to make climate-conscious decisions and the current and future workforce are fully equipped with the skills necessary to address the climate crisis.

171. Most (79 per cent) LT-LEDS indicated an intention to educate members of society through formal, non-formal or informal climate change education from primary to higher education and beyond, to promote and strengthen learners' knowledge, skills, values and action for adaptation and mitigation. Specific activities include integrating climate change into school curricula and national education plans and strategies, preparing pedagogical resources for teachers and students, and using the whole-of-school approach to make educational institutions and their operations more sustainable.

172. Most (85 per cent) LT-LEDS highlighted the role of awareness-raising in fostering behavioural change and climate literacy at all levels of society. Through diverse communication channels and tools, Parties plan to foster public understanding of the risks and potential impacts of climate change, as well as adaptation and mitigation measures. For example, Parties plan to implement information campaigns, events and dedicated days on

climate and energy that can reach the general public to help shape their consumption choices and the transition to a circular economy.

173. Most (83 per cent) LT-LEDS prioritized investment in training and professional development to build a skilled and qualified workforce that can adapt to changing job requirements. Technical and vocational education and training will be enhanced by governments, educational institutions and the private sector to facilitate current and future generations accessing decent work and quality jobs in a low-emission economy. The agriculture, building and energy sectors were highlighted as having significant demand for upskilling and reskilling.

174. Most (77 per cent) LT-LEDS stressed that ensuring public access to timely and relevant information is a prerequisite for effective and inclusive public participation in climate change decision-making and action (see paras 164–168 above), which some governments plan to facilitate by developing robust and efficient systems that collect and disseminate understandable and reliable climate information and are openly accessible by the public. Emphasis is also placed on making product information available to consumers through labelling schemes, particularly energy-efficiency labels for vehicles, household appliances and buildings.

3. Institutional arrangements

(a) Overview

175. Most LT-LEDS (84 per cent) indicated that institutional arrangements are crucial components for planning, coordinating and implementing climate change policy and action and for integrating climate change aspects into broader development planning. Some LT-LEDS (11 per cent) referred to institutional arrangements specifically established for their LT-LEDS preparation and implementation.

176. Many (57 per cent) LT-LEDS mentioned high-level governance settings for long-term low-emission development planning and for implementation of LT-LEDS, including those under the authority of the highest levels of national government, as well as within the framework of an ad hoc interministerial body with a coordinating function. The role of such formal institutional arrangements, as indicated in LT-LEDS, includes ensuring the integration of climate and development priorities, providing high-level endorsement to the LT-LEDS to place climate change at the heart of government decision-making, outlining an overarching vision for enhancing institutional capacities at all levels, preventing and minimizing possible challenges and trade-offs through coordination, ensuring effective coordination and providing strategic orientation in achieving the long-term goal.

177. Some (35 per cent) LT-LEDS referred to thematic working groups for sectoral experts and stakeholders to exchange views and information with policymakers, generally under the umbrella of a designated public body. These instruments were described as essential, for example, for fostering the public debate on climate change; engaging with a wide range of stakeholders to share experience, evidence and analysis; understanding and taking into account the economic and social challenges; determining a common vision of the possible pathways towards economic prosperity, resilience and lower emissions; ensuring a joined-up and collaborative approach; promoting synergy with sectoral policies and identifying investment priorities.

178. Some (29 per cent) LT-LEDS described mandates, functions and objectives of consultative and advisory bodies composed of members appointed for their expertise, including generating climate-related knowledge based on the best available science, such as advice and recommendations for decision-making; identifying options for achieving climate goals in the most efficient and cost-effective way, including a selection of potential mechanisms and transition scenarios; providing multisectoral and multidimensional public policies assessments, including assumptions and models on which they are based; holding policymakers accountable for delivering on the targets set and ensuring consistency and completeness of reported data and information; ensuring that climate change is taken into account in all government policies; contributing to the development of monitoring

frameworks to facilitate implementation and continuous progress over time; and strengthening public trust, credibility and legitimacy of climate policies.

(b) Legal foundation

179. Some (38 per cent) LT-LEDS indicated that their long-term mitigation goal is formalized under national legislation. In their LT-LEDS, several Parties highlighted that a robust legal foundation is an effective means to guide actions at the national, regional and local level towards implementation with a view to facilitating coordination and coherence among a wide range of regulatory and economic instruments, contributing to achieving their long-term climate and development goals.

180. Other benefits of a legal foundation identified in LT-LEDS include facilitating cross-sectoral policy design and implementation; enhancing co-benefits and synergies between NDCs, SDGs and other national development plans; ensuring long-term planning and predictability beyond the efforts of a particular government; influencing consumer demand and choice to secure commitment to far-reaching changes; fostering forward-looking research, development and innovation policies; demonstrating leadership and commitment to international cooperation towards global transformation; transforming energy systems into efficient and low-carbon alternatives; reducing the cost of low-emission technologies and enabling their deployment at speed and scale; and promoting the transition to a circular economy.

(c) Monitoring progress

181. Most (82 per cent) LT-LEDS provided information on formal arrangements for monitoring and reporting on progress of LT-LEDS implementation. Some (26 per cent) LT-LEDS indicated requirements to report the implementation of measures annually and a few (9 per cent) indicated requirements to report every two years. Overall, Parties illustrated a consolidation of their monitoring and reporting frameworks as part of the planning and implementation of their LT-LEDS.

182. When specified, indicators and reporting elements included quantified data such as GHG emissions, sink capacity, economic and energy statistics for the current situation and for intermediate and long-term targets; and qualitative descriptions by sector, including but not limited to agriculture, buildings, energy, industry, LULUCF, transport and waste, to inform on the achievement of domestic policies and measures.

4. Update

183. Four updated LT-LEDS were communicated in 2021, before COP 26. CMA 3 invited Parties to update LT-LEDS regularly, as appropriate, in line with the best available science.[36] A total of four updated LT-LEDS were communicated as at 23 September 2022.

184. In addition, most (85 per cent) LT-LEDS reported the intention of Parties to regularly update their LT-LEDS, drawing on different objectives, such as creating an enabling environment for steadily increasing ambition; reflecting building on the main lessons learned from the monitoring of progress, including identifying and correcting technology and regulatory lock-in effects that contradict the long-term goal; encouraging alignment of sectoral short-term targets, planning and policies given the timeline of sectoral policies tends to be shorter than mid-century; allowing stakeholders to share their views and contribute to the design and revision of policies and measures; and maximizing synergies and alignment with new policies. Given many major changes can occur over a long-term period, including factors beyond the control of one country, Parties highlighted the iterative nature of LT-LEDS, often referred to as living documents, to reflect changes in technology, socioeconomic and political context, scientific knowledge and national capacity.

185. Many (64 per cent) LT-LEDS referred to frequency of updates. Every five years was the most widely indicated timeline, representing many (42 per cent) LT-LEDS (see figure 16).

[36] Decision 1/CMA.3, para. 33.

In addition, some (40 per cent) LT-LEDS indicated the timeline to review and update them is aligned with the timeline to update NDCs, so that LT-LEDS will guide subsequent NDCs.

Figure 16
Update frequency of long-term low-emission development strategies