Enhancing Action & International Cooperation for Accelerating Carbon Dioxide Removal Approaches

Discussion paper

May 29, 2025

Center for Climate and Energy Solutions[1]

A. Summary

1. The period from the end of the first global stocktake (GST) at COP28 (2023) through to COP30 (2025) is critical. During this time period we will learn the collective level of ambition of new climate targets, whether countries have taken into account the outcomes of COP28 in formulating them, and whether countries have put in place the domestic plans, legislation, finance and investment needed to implement those new targets. In the context of the Paris Agreement's ambition cycle, 2024-2025 are crucial years for preparation, action, and enhanced international cooperation.

2. The GST decision from COP28 sets out a number of key, transformational global targets and signals to Parties to: (i) inform their next nationally determined contributions (NDCs); and (ii) enhance implementation and international cooperation.[1] Parties were expected to communicate their NDCs by February 10, 2025, with an end date of 2035.[2] The GST signals form part of guidance and requirements emanating from Paris to date,[3] including that:
   - Each Party's successive NDC will represent a "progression" beyond its previous NDC and reflect its "highest possible ambition," reflecting its ***common but differentiated responsibilities and respective capabilities (CBDR-RC), in the light of different national circumstances***[4]
   - Parties "shall pursue domestic mitigation measures, with the aim of achieving the objectives" of their NDCs[5]
   - Parties include, as part of the information to facilitate clarity, transparency, and understanding of NDCs:

[1] This paper has benefited from the feedback, inputs, and insights from a number of experts, including Chris Neidl, Carbon Removals Lead, Climate Champions Team; Alexandra Deprez, Research Fellow, International Climate Governance, IDDRI; and Artur Runge-Metzger.

- how the Party considers that its NDC is fair and ambitious in the light of its national circumstances[6]
- how the NDC contributes toward
- achieving the objective of the Convention as set out in its Article 2[7]
- how the NDC is informed by the outcomes of the GST, in accordance with Article 4, paragraph 9, of the Paris Agreement[8]

- Parties come forward with ambitious, economy-wide emission reduction targets, covering all greenhouse gases, sectors and categories and aligned with limiting global warming to 1.5 degree C, as informed by the latest science, in the light of different national circumstances[9]
- Parties commit to accelerate action in this critical decade on the basis of the best available science, reflecting equity and the principle of CBDR-RC in the light of different national circumstances and in the context of sustainable development and efforts to eradicate poverty[10]
- Parties put in place new or intensify existing domestic arrangements for preparing and implementing successive NDCs[11]
- Parties are expected to present their next NDCs at a special event to be held under the auspices of the United Nations Secretary-General.[12]

3. In order to implement the GST targets and signals through enhanced NDC ambition and implementation, major barriers must be meaningfully addressed, turned into opportunities for enhanced international cooperation, and translated into development priorities and domestic policies.

4. This paper focuses on the GST decision's calls to Parties to:
   - **"accelerat[e] zero- and low-emission technologies, including, inter alia, renewables, nuclear, abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production"**[13]
   - **"conserve[e], protect[] and restor[e] nature and ecosystems towards achieving the Paris Agreement temperature goal, including through enhanced efforts towards halting and reversing deforestation and forest degradation by 2030, and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases and by conserving biodiversity, while ensuring social and environmental safeguards, in line with the Kunming-Montreal Global Biodiversity Framework."**[14,15]

5. Given their technological advancement and the expectation that scaling will reduce costs, this paper focuses on **the acceleration of the development and deployment of carbon dioxide removal (CDR) approaches,** which, as drawn from those two GST signals, includes both technological CDR[16] and nature-based CDR.[17]

6. According to the Intergovernmental Panel on Climate Change (IPCC), to have a reasonable chance of limiting warming to 1.5 degrees Celsius by the end of the century, fossil fuel use will need to be reduced drastically. CDR is needed to correct for expected residual greenhouse gas emissions from agriculture, to reduce carbon dioxide emissions from hard-to-abate industries like aviation, and to potentially counteract the risk of temperature overshoot through net-negative emissions.[18] However, the feasibility of aiming to reverse overshoot through extensive CDR deployment is highly uncertain, due to technical, economic, and sustainability constraints and limits. The science therefore calls for minimizing dependence on CDR by accelerating steep, rapid, and sustained emission cuts.

7. In the context of making the case for clear leadership to enable such action, this paper:
   - focuses on **the acceleration of the development and deployment of CDR approaches**

- sets out barriers and solutions, as identified by our work and others, that must be addressed and implemented to enable real action in 2025 with regards to CDR approaches[19]
- sets out key capacity building and leadership considerations, how existing efforts can be effectively utilized, and key priorities for 2025-26.

8. Parties have nevertheless not yet accelerated the energy transition to the global pace and scale necessary to achieve the goals of the Paris Agreement, despite repeated observations that shifting to renewable energy and increasing energy efficiency are "rational," the "right economic choice," "easy," or "obvious."[20] First, global production and use of fossil fuels has not declined. Second, some Parties may significantly increase their renewable energy capacity *and* continue to use—or even increase their use of—fossil fuels. It is essential to understand the reasons for this and address them.
9. Many of the **obstacles to accelerating the development and deployment of CDR approaches, including technological and nature-based CDR, can largely be boiled down to five immediate challenges**:
   - **lack of understanding of what CDR is and divergent views** on the need to start accelerating CDR deployment today[21]
   - evolving **market-based CDR policy frameworks**
   - **insufficient access to means of implementation**, such as finance and technology, as well as lack of institutional capacity and governance challenges, especially in developing countries
   - **land use tradeoffs and feasibility limitations**, especially for afforestation/reforestation, which can compete with other productive land uses and urbanization
   - **insufficient industrial and clean energy infrastructure** to enable technologically based removal activity[22] and long lead times to obtain permits and to build this infrastructure.[23]
10. Parties must respond quickly and tangibly in order **to accelerate the development and deployment of CDR approaches**. Several solutions and opportunities exist to help overcome these challenges. At the same time, clear leadership that is inspiring, inclusive, respects the nationally determined nature of NDCs and meets Parties and NPS where they are in terms of capacity, is essential. Enhanced international cooperation is vital to move from incrementalism to transformative levels of action in 2025 and beyond.

The GST decision sets out critical mitigation targets and signals.[24] The achievement of no one signal or target alone will result in the deep, rapid, and sustained reductions in greenhouse gas emissions in line with 1.5 degree C pathways.

To accelerate the development and deployment of CDR approaches, Parties could usefully support a dedicated, inclusive **"umbrella" international cooperative initiative to drive enabling conditions applicable to all CDR approaches for their integration across sectors, as relevant**. For example, this overarching initiative could consolidate and build on the work of: (i) international governmental organizations (IGOs), such as the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the G7, and the G20; (ii) United Nations (UN) agencies, such as the UN Environment Programme (UNEP), the Technology Executive Committee (TEC) at the UN Framework Convention for Climate Change (UNFCCC), and the UN Industrial Development Organization (UNIDO); (iii) voluntary initiatives, such as Mission Innovation (MI) CDR Mission and the Carbon Management Challenge (CMC); and (iv) non-Party stakeholders (NPS) (see "Annex IV: Examples of Effective Policies and Programs

for CDR Development and Deployment" for more detail on NPS-led CDR efforts). The Troika of COP Presidencies, as a leader on ambition, and Brazil, as COP30 Presidency, could invite these organizations and stakeholders to work together, based on their expertise, through dedicated workstreams that would address specific barriers and enablers.

The workstreams for this cooperative initiative could focus on catalyzing the following enabling conditions:

- **Enabling condition 1:** For countries that intend to rely on CDR to achieve their NDCs, establish CDR targets aligned with long-term low greenhouse gas emissions development strategies (LT-LEDS), and a roadmap by CDR approach for their achievement, while ensuring the primacy of emissions reductions and that sustainability limits are not crossed.
- **Enabling condition 2:** Develop a CDR cross-sectoral policy landscape for greater market transparency and investments at scale, aiming to achieve NDC targets.
- **Enabling condition 3:** Provide socio-political support toward public acceptance of CDR approaches for CDR uptake in local contexts.
- **Enabling condition 4:** Leverage existing UNFCCC workstreams and climate cooperative initiatives for capacity building and enhanced international cooperation to enable sectoral integration of CDR approaches.

The Presidency Troika's leadership approach, including Mission 1.5, provides a unique opportunity to set out a new model for collaborative leadership. Building on the GST targets and signals from the UAE Consensus, COP30 in Belém must reflect on the level of ambition presented by the NDCs and set the new direction as we head toward the end of this critical decade.

Questions for Consideration

- How are Parties planning to take forward the GST signals that relate to the acceleration of the development and deployment of CDR approaches? How do they intend to reflect this in new NDCs, or future updates of submitted NDCs, including through the provision of information to facilitate clarity, transparency and understanding?
- How can Parties best be supported in efforts to accelerate development and deployment of CDR approaches?
- How can Parties balance the acceleration of CDR approaches while also prioritizing emissions reductions at speed and scale?
- What is the plan to enhance international cooperation on the acceleration of the development and deployment of CDR approaches?

B. Context

11. The GST is a key part of the Paris Agreement's "ambition cycle."[25] Parties to the Paris Agreement are required to undertake a GST every five years "to take stock of the implementation of this Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals. It shall do so in a comprehensive and facilitative manner, considering mitigation, adaptation and means of implementation and support, and in light of equity and the best available science."[26]

12. The outcome of the GST shall inform Parties in: (i) updating and enhancing, in a nationally determined manner, their actions and support (including their NDCs); and (ii) enhancing international cooperation for climate action.[27] The GST outcome also reaffirms sustainable and just solutions founded on meaningful, inclusive participation of all stakeholders and underlines that just transitions can support more robust and equitable mitigation outcomes.[28]

13. Parties were encouraged to communicate their NDCs by February 10, 2025, with an end date of 2035.[29] There are guidance and requirements for their NDCs that have been set out by Parties from Paris through to COP28 (see "Summary" above).

14. CDR refers to "anthropogenic activities that remove carbon dioxide from the atmosphere and store it durably in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological, geochemical, or chemical carbon dioxide sinks, but excludes natural carbon dioxide uptake not directly caused by human activities."[30] For a more detailed definition of CDR approaches, please see "Annex I: Understanding Carbon Removal and Management Approaches."

15. As of September, 2024, 148 countries have set net-zero targets that are likely to rely on CDR to some extent.[31] However, according to the October 2024 *NDC Synthesis Report*, only 50 percent of Parties have provided information on long-term mitigation visions, strategies, and targets up to and beyond 2050 in their NDCs.[32] The few references to removal projections in Parties' NDCs are for the most part not quantified removal targets, beyond bulk estimates in the Agriculture, Forestry and Other Land Use (AFOLU) sector, and provide little specificity as to which CDR approach would be used and when.[33] For example, 80 percent of NDCs cover AFOLU, but mitigation outcomes from emissions reductions and CDR are largely not identified separately.

16. Of the LT-LEDS that countries have voluntarily submitted up to September 2023, 56 percent described long-term mitigation goals in terms of net-zero greenhouse emissions, while 4 percent referred to net-zero carbon dioxide emissions.[34] 87 percent of LT-LEDS referred to a role for increased forest area by afforestation and reforestation activities to achieve long-term low-emission targets. While these long-term visions imply some level of CDR, only 41 percent showed the level of removals in long-term emissions projections.[35] There is no clear UNFCCC guidance on how Parties should reference or track CDR in NDCs and LT-LEDS.

17. The years 2024-2025 are crucial to take forward the GST targets and signals, translating them into effective domestic policies and measures as well as enhancing international cooperation on climate action. The moment of truth as to whether the GST, in the wider context of the Paris Agreement's ambition cycle, will have succeeded in increasing ambition will be in 2025 when new NDCs must be tabled by all Parties. The collective impact of these will be set out in a synthesis report to be made available ahead of COP30.[36] Furthermore, COP30 in Belém should not be seen as a cliff edge; it will need to set out the world's response to level of ambition that countries have come forward with.

Accelerating Development and Deployment of CDR Approaches: From Incremental to Transformational Change

18. According to the IPCC, to have a reasonable chance of limiting warming to 1.5 degrees Celsius by the end of the century, fossil fuel use will need to be reduced drastically. In pathways that limit warming to 1.5 degrees C with no or limited overshoot—even with assuming significant use of technologies like CDR—global use of coal must fall by 95 percent by 2050, oil by about 60 percent, and gas by about 45

percent. CDR is needed to correct for expected residual greenhouse gas emissions from agriculture, to reduce carbon dioxide emissions from hard-to-abate sectors like aviation, and potentially to counteract the risk of temperature overshoot through net-negative emissions.[37]

19. It is important to note that the feasibility of aiming to reverse overshoot through extensive CDR deployment is highly uncertain, due to technical, economic, and sustainability constraints and limits.[38] The science therefore calls for minimizing dependence on CDR by accelerating steep, rapid, and sustained emission cuts from decarbonization, including by implementing the targets and signals of the GST, such as transitioning away from fossil fuels, tripling renewables, doubling energy efficiency, and halting and reversing deforestation by 2030.[39]

20. Several countries, including each of the Troika of COP Presidencies, have launched economic diversification strategies and foreign direct investment goals to move away from fossil fuel production economic dependency, where investments in technological and nature-based removals are sometimes referenced. For example, the United Arab Emirates (UAE)'s diversification plans[40] connect to its 2024 NDC 3.0, reiterating the country's commitment to 'net negative emissions' after reaching net zero by 2050.

21. UAE's current NDC points to investments in mangrove afforestation, microalgae growth. and direct air carbon capture and storage (DACCS), among other CDR approaches toward an interim 2035 removal target of 9.3 $MtCO_2$-e.[41] Azerbaijan has focused on a green transition through renewable energy and investment in low-carbon technologies, without specific mention to CDR; Brazil has launched a bioeconomy strategy, including nature-based CDR.[42]

22. Brazil's strategy includes an emissions trading system (ETS), launched in 2024, with offsetting flexibility, which facilitates the use of carbon credits in meeting its decarbonization goal. This flexibility in its ETS design is part of the national strategy to maximize Brazil's high potential for removals, especially land-based CDR, BECCS,[43] and biochar,[44] reflected as removals from the AFOLU sector in Brazil's NDC 3.0.[45]

23. Globally, CDR deployment is below what is needed to achieve net zero by 2050. The "State of Carbon Dioxide Removal," a global, independent scientific assessment of CDR, notes that current CDR is around 2 $GtCO_2$/year. Despite the fact that only 0.1 percent—or 0.0013 Gt—of removal is from novel methods, these methods are growing more rapidly than conventional approaches.[46] The authors of the first two "State of Carbon Dioxide Removal" reports—largely IPCC authors—are developing open CDR databases and producing a scientific assessment of us of CDR in the upcoming round of NDCs. The new report will include recommendations on enhancing international cooperation.[47]

24. According to the IEA,[48] neither carbon capture usage and storage (CCUS) as a broader category of carbon management technologies, nor BECCS or DACCS as specific novel CDR approaches within CCUS are on track, with BECCS[49] falling behind DACCS[50] in a net-zero emissions by 2050 scenario.[51] (Please refer to "Annex I: Understanding Carbon Removal and Management Approaches" for more detail on these technology categories.) Recent indications may show that CDR approaches that are part of CCUS are headed in the right direction, however.[52]

25. On nature-based conventional CDR, UNEP shows that by 2030, reforested land area would need to increase by 77 percent relative to 2024, while a more than ten-fold increase is needed in peatland and mangrove restoration. Data to track agricultural CDR solutions is insufficient.[53]

26. In the UNFCCC, the UN Climate Change High Level Champions (HLCs), who connect the work of Parties with the main voluntary and collaborative actions taken by cities, regions, businesses, and investors, established a global "breakthrough"[54] target for CDR. Breakthroughs are moments that mark a significant advance in the transformation of an economic sector or natural system. To catalyze systems' transformation carbon dioxide removals are responsibly scaled to remove 3.5 billion tonnes of carbon dioxide per year by 2030. 500 million tonnes of this must be stored for at least 100 years (3 billion tonnes per year of carbon dioxide is stored for decades to centuries).

27. The tracking of progress in the development and deployment of CDR approaches depends on several factors: the reference CDR scenario; the capacity to address quantification and reporting challenges for each approach in that scenario; and the limits to implementation imposed by safeguards and sustainability considerations. See "Annex III: Existing Efforts to Enhance CDR Accounting and Scenarios for Progress Tracking" Annex III: Existing Efforts to Enhance CDR Accounting and Scenarios for Progress Trackingfor more detail on efforts at the UNFCCC and in the broader climate ecosystem to enhance CDR accounting and reference scenario development for progress tracking.

28. In recognition of the need for deep, rapid, and sustained reductions in greenhouse gas emissions in line with 1.5 degree C pathways, the COP28 GST decision called on Parties to contribute to, in a nationally determined manner, accelerating zero- and low-emission technologies, particularly in hard-to-abate sectors, and enhancing terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases. Read together, these signals support **the acceleration of the development and deployment of CDR approaches**, including technological and nature-based CDR.

Barriers and Solutions to Accelerating the Development and Deployment of CDR Approaches

29. Despite repeated observations and exhortations by some that shifting to renewable energy and increasing energy efficiency is "rational," the "right economic choice," "easy," or "obvious," Parties have nevertheless not yet accelerated the energy transition to the global pace and scale necessary to achieve the goals of the Paris Agreement. First, global production and use of fossil fuels has not declined. Second, some Parties may significantly increase their renewable energy capacity *and* continue to use fossil fuels, with their use increasing in some cases.[55] It is essential to understand and engage with the reasons for this.

Barriers

30. Parties still face a number of regulatory, economic, social, and technological barriers to accelerating the development and deployment of CDR approaches. For these technologies to be cost competitive in the 2030s, research, development, and demonstration (RD&D) and pilot projects for novel CDR approaches are needed in this decade.

31. However, the foremost barrier has been the ongoing debate over the extent to which CDR will and should play a role in net-zero scenarios. A key concern is that anticipated reliance on CDR approaches could divert efforts away from achieving needed early emissions reductions, locking in fossil fuel infrastructure and high greenhouse gas emitting practices.[56] Some opponents stress the uncertainties—for instance, the permanence of removals—associated with CDR technologies. Some emphasize the need to ensure investment in removals do not undermine investments in more cost-effective, rapid emissions reductions needed in this critical decade, such as generated by renewable energy and energy efficiency solutions. Research shows the need to provide clarity and confidence on how carbon removals differ from emissions reductions, so as to keep the latter in focus and address

technical knowledge gaps for building systems that can support the development of CDR approaches.[57]

32. As identified by C2ES,[58] the GST's *Technical Dialogue Synthesis* report,[59] and other sources, other challenges include:

- a lack of understanding of what CDR is, how it differs from emissions reductions, and the potential for emissions reductions to be deemphasized (deterrence risks)[60]
- a lack of capacity for the design and modelling of different CDR pathways and approaches based on durability, readiness, affordability, and investment timeline
- underdeveloped and evolving market-based CDR policy frameworks and legal ownership instruments for removal units
- lack of: access to finance, including start-up, infrastructure, or adaptation finance to address high upfront capital costs; technology transfer; and institutional or regulatory capacity as well as governance challenges, especially in developing countries
- land-use tradeoffs or conflicts, as well as sustainability and feasibility limitations, especially for afforestation/reforestation, such as competition with other valuable or productive land use and urbanization, reinforced by:
    - pressures from large-scale commodity production and extractive industries, as well commodity demand from developed countries
    - issues of land rights, institutional fragmentation, under-resourcing of services, and reactive governance across competing policy domains
- technological CDR infrastructure bottlenecks, including access to clean energy sources[61] and long lead times to obtain permits to build and operate this infrastructure[62]
- lack of economic incentives to shift away from high-emission activities, either because of existing subsidies and the lack of taxes or emissions limits, or insufficient economic incentives for CDR implementation as a revenue-generating alternative to high-emissions activities[63]
- permitting and other regulatory hurdles
- the need for greater public acceptance of technological CDR given perceived tradeoffs with the Sustainable Development Goals (SDGs).[64]

Solutions

33. A number of high-impact solutions and opportunities to address key challenges have been identified through efforts across different fora. The following list draws from C2ES's work, as well as the HLCs *2030 Climate Solutions*:[65]

Actions, solutions, and enablers for the acceleration of development and deployment of CDR approaches
34. Redirecting funding from fossil fuel subsidies and investments, carbon pricing instruments,[66] and canceled debt payments to finance the creation and implementation of national just energy transition funds and plans (Source: C2ES)
35. Conducting extensive consultation campaigns involving all affected stakeholder to facilitate public acceptance and buy-in from different sectors (Source: C2ES)
36. Facilitating capacity building for workforce development and regulatory/governance bodies within the renewable energy sector (Source: 2030 Climate Solutions), since the availability of renewables is a condition for making energy intensive CDR solutions viable.
37. Ensuring opportunities for community ownership of CDR technologies and facilitating efforts to ensure a just and well-managed transition of skills and expertise into new jobs in the emerging carbon removal sector (Source: 2030 Climate Solutions)

• Providing updated assessments on the state of individual CDR methods regarding costs, potentials, hazards, co-benefits, technology readiness, potential, and other factors (Source: 2030 Climate Solutions)
• Designing policy instruments and evaluation criteria in areas such as monitoring, reporting, and verification (Source: 2030 Climate Solutions)
• Establishing public-private partnerships that can scale up the technology faster, provide the necessary funding for RD&D activities, create demand for carbon removals through procurement programs, and facilitate stakeholder engagement activities (Source: 2030 Climate Solutions)
• Assembling a more complete picture of research and innovation across countries and methods, similar to the process followed by the IEA for energy RD&D and by IRENA for tracking renewable projects and their pipelines (Source: 2030 Climate Solutions)
• Ensuring policy support mechanisms evolve beyond RD&D to cultivate market acceptance and address the unique challenges that early CDR adopters face in demonstrating the commercial viability of new technologies and approaches (Source: C2ES)[67]

38. The **HLCs and the Marrakech Partnership for Global Climate Action** identify impactful climate solutions and opportunities for international cooperation.[68] At COP28, in the context of the conclusion of the GST and building on prior work, the HLCs presented the *2030 Climate Solutions*—an Implementation Roadmap that sets out solutions framed in specific actions, with insights from a wide range of NPS on effective measures being undertaken that need to be scaled up and replicated as well as current gaps that need to be bridged.[69] The 2030 Climate Solutions recommend key actions and means of implementation for achieving key targets for clean power by 2030.[70] These recommendations overlap with high-impact opportunities and solutions to address barriers to accelerating CDR, as also identified in work by C2ES.[71]

C. Leadership for Accelerating Development and Deployment of CDR Approaches

39. As an outcome of the UAE Consensus, the COP28 Presidency (UAE) has been working together with the Azerbaijan (COP29) and Brazil (COP30) Presidencies to drive ambitious collective action, including through the "Roadmap to Mission 1.5C," an initiative to significantly enhance international cooperation and the international enabling environment to stimulate ambition in the next round of NDCs. This configuration has been called "the Troika." The Troika, together with the G7 and G20 and including through the Roadmap to Mission 1.5C, broadly seek to drive ambition and enhanced international cooperation.

40. There have largely been no coordinated efforts to make progress on the GST signals that relate to the acceleration of the development and deployment of CDR approaches. Current work has incrementally focused on understanding and overcoming challenges related to strategy and implementation. These challenges include: CDR accounting (quantification and reporting), including CDR-specific safeguards and sustainability considerations that are not fully developed nor standardized under the UNFCCC; the extent to which CDR plays a role in global mitigation pathways; and the tracking of CDR.

41. Since CDR encompasses different sector-specific approaches and technologies, best practice guidance is found across different organizations focusing on specific sectors, including IGOs, country-led coalitions, public-private cooperative initiatives, and jurisdictions. There are several actors that have

engaged with CDR in different applications. These efforts could be coordinated to support CDR approaches across sectors.

42. In the broader climate ecosystem, the Mission Innovation (MI) CDR Mission was launched as a country-driven climate cooperative initiative at COP26 to accelerate innovation of technologies for CDR specifically, including in the AFOLU sector, toward enabling 100 million tonnes of technological CDR per year by 2030.[72] It has nine country participants engaging with NPS on the mission including through innovation prizes and targeted campaigns.[73] While focused on innovative or novel CDR approaches (see "Annex II: Characteristics of Different Carbon Dioxide Removal Solutions and the Importance of Enabling Conditions for Sectoral Integration" for more detail on CDR categories), the MI CDR Mission provides a data visualization tool on biogenic CDR potential including in the forestry sector, providing valuable information for nature-based conventional CDR approaches such as afforestation/reforestation.

43. The Carbon Management Challenge (CMC) was launched ahead of COP28 as a country-driven climate cooperative initiative to scale carbon capture and storage technology associated to both emissions reduction and removal activities. It aims to advance a pipeline of carbon management projects by 2030, that will manage 1 Gt of carbon dioxide or more annually when fully operational.[74] The CCS Institute acts as secretariat of the CMC coordinating 23 country participants around finance, deployment and engagement workstreams. The CMC works with the Clean Energy Ministerial (CEM) CCUS Initiative and MI CDR Mission, seeking to engage with NGOs, industry and finance entities, international organizations and research institutions.[75]

44. The IEA is tracking progress on the transition away from fossil fuels in energy systems so as to achieve net zero by 2050, which was set out in paragraph 28 of the GST decision.[76,77] The tracker, based on the *IEA's Net Zero Emissions by 2050 Scenario* and the latest data analysis, shows where the world currently stands in relation to these objectives, as well as where it would need to be in 2030 to meet them. Pathways for BECCS and DACCS and are embedded in the IEA net-zero scenario and are being tracked as part of the GST outcome.

45. Focused on tracking the tripling of renewable capacity GST target, IRENA has issued several publications on CDR technologies and their role alongside renewables in the deep decarbonization of energy systems.[78]

46. Given their competitive advantage on several CDR approaches, G7 countries could signal their engagement in enhancing the development of CDR approaches in both developed and developing economies, including during Canada's 2025 Presidency. Canada recently announced a more than CAD 9.5 million investment in innovative carbon management technologies, including DACCS and BECCS,[79] and is well positioned to become a leader in supplying technological CDR solutions. Other G7 countries are poised to lead in CDR deployment. The United States and Switzerland have been recognized as leaders in DACCS project capacity; Sweden and Denmark are leaders in BECCS.[80] On the demand side, the United States, the UK, and Norway are primary durable CDR buyers based on 2024 market data.[81]

47. G20 countries also have significant CDR potential, particularly in the AFOLU and energy sectors.[82] South Africa as G20 Presidency in 2025 could provide CDR a space in the agriculture, energy transitions and environment, or climate sustainability working groups.[83]

48. The above reflects the need for focused leadership to specifically drive progress on the acceleration and deployment of CDR approaches.

2025 CDR-related Events

49. Energy-related organizations, coalitions, and initiatives may meet or engage on CDR approaches at a number of high-level clean energy or energy innovation-related events for 2025. These events include:

JANUARY
11–13 January, Fifteenth Session of the IRENA Assembly
15 January, International Emissions Trading Association (IETA) Middle East and North Africa (MENA) Carbon Market Dialogue (Abu Dhabi, UAE)
14–16 January, Abu Dhabi Sustainability Week - World Future Energy Summit (Abu Dhabi, UAE)
FEBRUARY
6 February, The Economist 1st annual Carbon Capture and Storage Summit (Amsterdam, Netherlands)
11 February, Pathway to NDC 3.0 (virtual)
11–13 February, World Governments Summit (Dubai, UAE) • *Troika event on transforming climate ambition and implementation*
25–27 February, CLIMIT Summit 2025 (Larvik, Norway) *In partnership with Mission Innovation CDR*
21–28 February, Oman Climate Week (Muscat, Oman)
MARCH
6–7 March, Powering Africa Summit (Washington, DC)
7 March, The Role of Non-Party Stakeholders in Shaping NDCs 3.0 in the Caribbean (virtual)
17 March, Global Direct Air Capture Conference (New York, NY, USA)
24–26 March, Peterberg Dialogue (Berlin, Germany)
25–27 March, Ocean Vision Biennial Summit 2025 (Vancouver, Canada) *Focusing on marine CDR*
APRIL
1 April, NDC 3.0 Enhanced Ambition and Needs (virtual)
1–3 April, IETA European Climate Summit (ECS) 2025 (Lisbon, Portugal)
1–2 April, The BioCCUS Conference 2025 (Stockholm, Sweden) *Hosted by Klimpo*
8 April, Americas Forum on Carbon Capture and Storage (Washington DC, USA) *Organized by the Global CCS Institute and the Embassy of Canada on financing, national strategies and policies*
8 April, ClimateHack Zürich: Beyond the Hype: Is Carbon Removal Delivering?
21–24 April, Global Biochar Exchange 2025 (Nagoya City, Japan) *Organized by the International Biochar Initiative*
21–26 April, World Bank and International Monetary Fund Spring Meetings (Washington, DC)
30 April, Carbon Catalyst (Calgary, Canada) *Organized by the Pembina CDR Centre*
MAY
13–15 May, S&P Global Carbon Management Americas 2025 (Denver, USA)
19–23 May, UNFCCC Climate Week Panama (Panama City, Panama) • *19-20, Fifth global dialogue and investment-focused event under the Sharm el-Sheikh Mitigation Ambition and Implementation Work Program* • *22-23, Third Dialogue under the United Arab Emirates Just Transition Work Program* • *NDC Clinics*
20–21 May, Carbon Unbound 2025: Accelerating Gigaton-Scale carbon Dioxide Removal (New York, USA) *A CDR Business Summit*
27-28 May, SDG-Climate Synergies Conference (Copenhagen, Denmark)
JUNE
3 June, C-Carbon Carbon Removal Investment Summit (London, UK) *Focusing on data modelling*

16–26 June, SB60 (Bonn, Germany) • Annual GST NDC dialogue
10–12 June, Innovate4Climate (I4C) 2025 (Seville, Spain) *Organized by the World Bank, in collaboration with the International Carbon Action Partnership and International Emissions Trading Association*
10–13 June, International Energy Workshop (IEW) 2025 (Nara, Japan) *Organized by the Research Institute of Innovative Technology for the Earth (RITE)*
11–13 June, IEA Xth Annual Global Conference on Energy Efficiency (Brussels, Belgium) *Just energy transition will be a focus of this conference*
15–17 June, G7 Summit (Kananaskis, Alberta, Canada)
21–29 June, London Climate Action Week (London, UK)
10–13 June, International Energy Workshop (IEW) 2025 (Nara, Japan) *Organized by the Research Institute of Innovative Technology for the Earth (RITE)*
JULY
8–10 July, IETA Asia Climate Summit (ACS), Bangkok, Thailand
TBD, UNFCCC Ministerial on Climate Action (MoCA) (TBD)
AUGUST
23–29 August, Rio Climate Action Week (Rio de Janeiro, Brazil)
25–27 August, Clean Energy Ministerial and Mission Innovation (CEM16-MI10) Ministerial Meeting (Busan, South Korea)
26–28 August, IETA Latin America Climate Summit (LACS) 2025 (Sao Paulo, Brazil)
SEPTEMBER
1–5 September, UNFCCC Climate Week Ghana (Accra, Ghana) (TBC)
2–3 September, Carbon Capture Global Summit 2025 (London, UK) *Focusing on CCUS*
18 September, G20 Agriculture Working Group Ministerial Meeting (Somerset West, South Africa)
10–24 September, UN General Assembly (New York, NY)
21–28 September, NY Climate Week (New York, NY)
23-25 September, IETA North America Climate Summit (NACS) 2025 (New York, USA)
23 September, G20 Research and Innovation Working Group Ministerial Meeting (Pretoria, South Africa)
26 September, G20 Energy Transitions Working Group Ministerial Meeting (Kruger National Park, South Africa)
29 September-3 October, Baku Climate Action Week (Baku, Azerbaijan)
30 September to 3 October, Xth Latin America and the Caribbean Energy Week (X^{ma} Semana de la Energia, OLADE) (Santiago, Chile)
OCTOBER
7–9 October, NDCs 3.0 Regional Forum for Africa (Kigali, Rwanda)
14–15 October, Pre-COP (Brasilia, Brazil) *Troika of COP Presidencies High-level Dialogue to focus on NDC ambition and implementation to date*
NOVEMBER
10–21 November, COP30 (Belem, Brazil) • *High-level ministerial roundtable for the Mitigation Work Program.* • *High-level ministerial roundtable for the United Arab Emirates Just Transition Work Program* • *UAE Dialogue*
22–23 November, G20 Summit (South Africa)
DECEMBER
1–12 December, Seventh UN Environment Assembly (UNEA-7) (Nairobi, Kenya)

Capacity Building and Support for the Development and Deployment of CDR Approaches and NDCs

50. Other initiatives can provide critical capacity-building support for the development of climate policy and NDCs. One key initiative is **UN Development Programme (UNDP)'s Climate Promise**.[84] Climate Promise leverages Parties' NDCs and brings together UNDP's infrastructure, networks and breadth of substantive offers to provide comprehensive support on NDC implementation. UNDP provides support to help countries take bold action to reduce their emissions, increase their resilience to climate impacts and support sustainable development priorities.

51. In April 2024, UNDP unveiled the next stage of Climate Promise, Climate Promise 2025, which supports countries in developing and delivering their pledges and draws on UNDP's newly established Climate Hub.[85] Climate Promise 2025 links climate diplomacy and thought leadership with climate action and sustainable development at national and local levels to align the next generation of NDCs with the Paris Agreement goals.

52. Another key initiative is the **NDC Partnership**.[86] Leveraging more than 240 members and more than 80 institutions, the Partnership responds to requests for support needed to translate identified NDC implementation priorities into actionable policies and programs. Based on these requests, the membership offers a tailored package of expertise, technical assistance, and funding. This collaborative response provides developing countries with efficient access to a wide range of resources to adapt to and mitigate climate change and foster more equitable and sustainable development.

53. In June 2024, the NDC Partnership and the UNFCCC secretariat launched the **NDC 3.0 Navigator**. The NDC 3.0 Navigator is an interactive tool designed to support countries in raising NDC ambition and accelerating the implementation of the next round of NDCs. It brings together expert-created strategies, resources, and country insights to support countries in updating their NDCs.[87] The NDC Navigator sets out tools and strategies to translate "global efforts" to rapidly scale up the deployment of existing technologies and to foster the innovation and the development and transfer of new technologies into national efforts."[88] Useful related resources include the CCS Institute's assessment of how carbon management (including both emissions reductions and CDR solutions) is referred to in current NDCs and in recommendations for NDCs 3.0.[89]

54. Within the UNFCCC, the Technology Executive Committee (TEC), as the policy arm of the Technology Mechanism, also provides important capacity building support. TEC focuses on identifying policies that can accelerate the development and transfer of low-emission and climate resilient technologies. TEC developed a policy brief with the United Nations Industrial Development Organization (UNIDO) to provide concrete policy and technology options to reduce emissions from hard-to-abate industries and with a view to advance the inclusion of those industries in updated NDCs.[90]

Recommendations

55. The GST decision sets out critical mitigation targets and signals.[91] The achievement of no one signal or target alone will result in the deep, rapid, and sustained reductions in greenhouse gas emissions in line with 1.5 degree C pathways.

56. To accelerate the deployment of CDR approaches at large, international cooperation is needed to establish clear, interoperable, and cross-cutting CDR policy frameworks to enhance investments and accelerate project development of different kinds of CDR activity depending on local circumstances and competitive advantages (see "Annex II: Characteristics of Different Carbon Dioxide Removal Solutions and the Importance of Enabling Conditions for Sectoral Integration" for more information). There is still a significant need to deepen understanding of CDR, how to account for it, the relevance of different approaches in global and national mitigation pathways, and incentives for their development.

57. Given these challenges, **Parties could usefully support a dedicated, inclusive "umbrella" international cooperative initiative to drive enabling conditions applicable to all CDR approaches for their integration across sectors**, **as relevant**.

58. For example, this overarching initiative would consolidate and build on the work of: (i) IGOs (e.g., IEA, IRENA, the G7, and the G20); (ii) UN agencies (e.g., UNEP, the TEC at the UNFCCC, and UNIDO); (iii) voluntary initiatives such as MI CDR Mission and the CMC; and (iv) NPS (see "Annex IV: Examples of Effective Policies and Programs for CDR Development and Deployment" for more detail on NPS-led CDR efforts). The Troika of COP Presidencies, as a leader on ambition, and Brazil, as COP30 Presidency, could invite these organizations and stakeholders to work together, based on their expertise, through dedicated workstreams that would address specific barriers and enablers.

59. Such an international cooperative initiative could effectively guide workstreams focused on catalyzing the following enabling conditions:

- **Enabling condition 1:** For countries that intend to rely on CDR to achieve their NDCs, establish CDR targets that are aligned with LT-LEDS and a roadmap by CDR approach for their achievement, while ensuring the primacy of emissions reductions and that sustainability limits are not crossed
- **Enabling condition 2:** Develop a CDR cross-sectoral policy landscape for greater market transparency and investments at scale, to help achieve NDC targets
- **Enabling condition 3:** Provide socio-political support toward public acceptance of CDR approaches for CDR uptake in local contexts
- **Enabling condition 4:** Leverage existing UNFCCC workstreams and climate cooperative initiatives for capacity building and enhanced international cooperation to enable sectoral integration of CDR approaches.

Enabling Condition 1: For countries that intend to rely on CDR, Establish CDR Targets in NDCs Aligned with LT-LEDS and a Roadmap by CDR Approach

60. In the context of a broader mitigation and a just transition strategy, Parties could establish one or more separate CDR targets as part of their NDCs, aligned with their LT-LEDS, working with capacity building initiatives and the IPCC on overcoming quantification challenges as needed.[92] CDR targets (distinct from emissions reduction targets) can focus mitigation efforts on removals while still

prioritizing emissions reductions.[93] An LT-LEDS-aligned roadmap for the achievement of CDR targets—differentiated by removal activity type—would also help send clear signals to investors and financial institutions involved in project implementation requiring infrastructure development with longer lead times.[94]

61. Under this condition, CDR targets would consider the comparative advantages of national and regional natural resource and infrastructure in the selection of CDR approaches and their implementation roadmap. A roadmap would indicate an estimate of the order and means of implementation needed for different CDR solutions, in light of their marginal abatement cost curves (that is, the cost of reducing or removing a ton of carbon dioxide equivalent).[95] These marginal abatement cost curves would have to consider sustainability risks, which limit the amount of feasible CDR, and just transition opportunities (that is, potential environmental and socio-economic net benefits, for example, related to economic diversification and the workforce) of CDR project deployment.

62. CDR targets should also consider prioritizing CDR approaches that durably counterbalance residual emissions that are truly hard to abate and enable net-negative emissions in the case there is overshoot.[96] For example, a CDR hierarchy would address the risk that CCS, as a subset of CDR technologies, is not used for emissions reductions that lock-in fossil-fuel emitting infrastructure.[97] It would also address the risk of overreliance on removals in the AFOLU sector given the challenges of accounting for land-based carbon uptake in national greenhouse gas inventories.[98]

Enabling Condition 2: Develop a CDR Cross-sectoral Policy Landscape

63. Cross-cutting, inclusive leadership should support the development of more comprehensive CDR cross-sectoral policy that is more comprehensive and work to harmonize the landscape to provide more certainty and make information available. Developing the CDR cross-sectoral landscape means fostering the design of cross-sectoral supply- and demand-side policies and programs that increase the transparency of CDR activities, including verifiable information and business models to decrease the risk of investing in innovative CDR approaches and clear frameworks that reward investors. There are several policies and programs that provide additional incentives and guidance on CDR investments and related claims. These, however, do not generally encompass all kinds of CDR approaches. (Please refer to "Annex IV: Examples of Effective Policies and Programs for CDR Development and Deployment" for more information on these policies and programs).

Enabling Condition 3: Provide Socio-political Support toward Public Acceptance of CDR Approaches

64. Governments can promote broader acceptance of CDR approaches by making real economic diversification opportunities that enable just transition objectives across diverse sectors. CDR deployment could be tied to the delivery of net-positive sustainable development impacts. Policy guidance can enable project developers and local governments to support biodiversity conservation, community benefit plans, skills transfer, and workforce buildout, especially in the Global South.[99] For example, the mutual benefits of involving indigenous peoples and local communities are widely recognized by project developers, especially in the AFOLU sector.

65. Currently, there is a lack of research on the local impact of CDR approaches, especially when it comes to CDR technologies. Governments could commit to gather more evidence on CDR perceptions across

geographies. There are few studies on CDR perceptions from Africa, South/Central America, or Pacific countries other than Australia and New Zealand, despite high CDR potentials in these regions. There are even fewer studies that link the rapidly evolving policy context to public perceptions of CDR.[100]

Enabling Condition 4: Leverage Existing UNFCCC Workstreams and Climate Cooperative Initiatives for Capacity Building and Enhanced International Cooperation

66. The Troika of COP Presidencies could encourage Parties to use existing UNFCCC processes to advance work on the CDR-related signals in a just and equitable manner, in line with national priorities.[101] A focus on enhanced international cooperation toward implementation of the GST's outcomes with respect to CDR could define the conditions under which the deployment of all CDR approaches would enhance economic, environmental and social attributes of countries' development pathways. This definition could build on and complement existing work at the UNFCCC, including the MWP and JTWP, but also the work on removals by the Subsidiary Body for Article 6.4, and further engage NPS.

67. For example, the Sharm el-Sheikh Mitigation work program (MWP),[102] the UAE Just Transition Work Program (JTWP),[103] and work under the GST process could potentially be used facilitate dialogue, define guiding principles, and promote technical exchanges on CDR. Such spaces can focus on addressing barriers to implementation and define guiding principles to inform domestic planning and build investor confidence, focus on sector specific pathways that align with GST outcomes, and send signals through dialogue reports, COP decisions, and the action agenda.

68. The Subsidiary Body for Article 6.4 (the Paris Agreement Crediting Mechanism) will continue to provide best-practice guidance for measurement, reporting, and verification (MRV) and safeguards through more detailed standard guidance expected in 2025.[104] Following that, it will develop and approve specific CDR methodologies in the medium term, working closely with the IPCC on addressing accounting challenges.

Ongoing Leadership is Needed

69. The near-term goal is action and implementation that inform enhanced NDCs and ambition through 2025. In the longer-term, such leadership will be critical for informing subsequent implementation. Once there has been sufficient time to analyze the NDCs in the annual update of the NDC synthesis report that will be made available ahead of COP30, it will become clearer whether the GST will have succeeded.[105] But this also means that Belém will not be the "NDC COP." As such, 2025 will demonstrate how much more Parties are willing to commit to achieving the Paris goals. It is also possible that NDCs will reveal themselves to more usefully be investment plans or tools.[106]

70. The year 2025 will also mark the year that the Paris Agreement's enhanced transparency framework will be fully operational. New processes, like the facilitative multilateral consideration of process, provides opportunities for Parties to share best practices and lessons learned in implementing their NDCs.

71. Troika leadership and the incoming Brazilian Presidency must utilize the Roadmap to 1.5C and the outcomes of COP29 to skillfully build on progress toward a successful outcome at COP30 that nevertheless remains critical to ambition and enhanced international cooperation in 2026. COP30 in Belém should not be seen as a cliff edge, but a steppingstone to COP31 and beyond. In 2026, the second GST process begins again.

Conclusion

72. While there is a strong case for clear leadership to accelerate the development and deployment of CDR approaches within sustainability thresholds and minimizing dependence on CDR by accelerating steep, rapid, and sustained emission cuts, there is also a need for an inclusive approach. Clearer leadership on implementing and coordinating the acceleration of the development and deployment of CDR approaches, including how efforts are enacted on the ground, may elicit reactions that Parties are "being told what to do." As such, the national determinedness of NDCs and their domestic implementation must be clearly reiterated and respected.

73. At the same time, the value of clear leadership on the development and deployment of CDR approaches will enable far greater and faster implementation than would otherwise be the case. In addition, tracking progress toward its achievement at COP30 is crucial to generate further momentum. Early action must be captured in the next round of NDCs, laying a strong foundation for further efforts.

Annex I: Understanding Carbon Removal and Management Approaches

74. CDR falls somewhere along a spectrum of technological and nature-based approaches.[107] DACCS is an example of a purely technological approach. Processes that enhance the natural uptake of carbon dioxide into certain reservoirs, or use natural uptake to concentrate carbon dioxide for the purpose of subsequent engineered separation and storage, can be considered technological or hybrid forms of carbon removal. Examples include BECCS or enhanced mineralization of carbon dioxide in soils, the ocean, or the subsurface. Technological carbon removals are often considered "novel" CDR methods because they are in earlier stages of commercial readiness than nature-based removals. Nature-based removals are considered "conventional" CDR methods. They include afforestation, reforestation, and improved forest management; wetland restoration; and soil carbon sequestration (SCS). (See "Annex II: Characteristics of Different Carbon Dioxide Removal Solutions and the Importance of Enabling Conditions for Sectoral IntegrationAnnex II: Characteristics of Different Carbon Dioxide Removal Solutions and the Importance of Enabling Conditions for Sectoral IntegrationAnnex II: Characteristics of Different Carbon Dioxide Removal Solutions and the Importance of Enabling Conditions for Sectoral Integration" for a comprehensive categorization of CDR solutions.)

75. The IPCC notes that "[c]arbon capture and storage (CCS) and carbon capture utilization (CCU) applied to carbon dioxide from fossil fuel use are not CDR methods as they do not remove carbon dioxide from the atmosphere. CCS and CCU can, however, be part of CDR methods if the carbon dioxide has been captured from the atmosphere, either indirectly in the form of biomass or directly from ambient air, and stored durably in geological reservoirs or products."[108] Two of the leading technological carbon removal solutions, BECCS and DACCS, require the infrastructure of CCS or CCU for geological sequestration or utilization into other products.[109]

76. The IEA and others consider CCUS to refer to both CCS and CCU as part of a suite of carbon management technologies. CCUS is generally but not always associated with addressing point greenhouse gas emissions sources in hard-to-abate sectors, regardless of whether mitigation is achieved via emissions reductions or removals.[110]

Annex II: Characteristics of Different Carbon Dioxide Removal Solutions and the Importance of Enabling Conditions for Sectoral Integration

77. The science is clear that both reductions and removals are needed to reach global net zero by 2050. However, some civil society groups stress the "time value of carbon" as an key principle in setting priorities for mitigation action—in other words, that climate action now is critical to avoid increased concentrations of greenhouse gas emissions in the atmosphere that, cumulatively, will or could trigger climatic tipping points.[111] Rapid emissions cuts need to occur in this critical decade, especially the immediate and drastic reduction of potent, short-lived warming agents like methane, nitrous oxide, fluorinated gases, and black carbon.[112]

78. The proportion of mitigation activities that fall under CDR will have to increase over time in order to:
    - balance residual emissions (those emissions that could not be reduced by the decarbonization target year) in hard-to-abate sectors, which includes sectors that are critical for the transition away from fossil fuels (such as mining, steel, and cement).

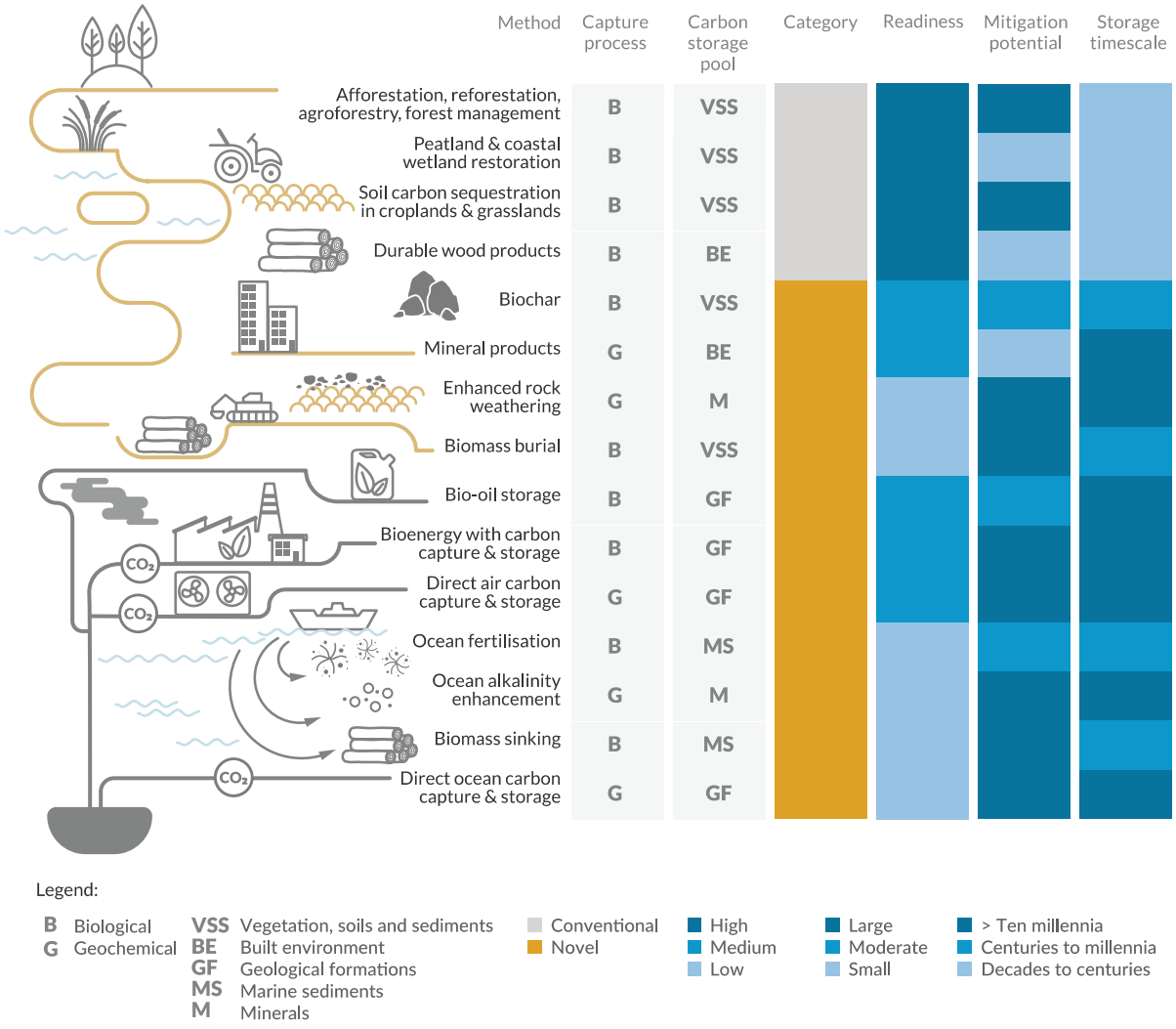
- consider risks of emissions overshoot, in line with the science
- address legacy emissions (those that were emitted before any attempt at reducing them was made) toward a net-negative world.

79. The science is also clear that a shift to CDR with durable storage methods and low "risk of reversal" (methods with low probability of carbon dioxide being released back to the atmosphere) is also needed. Removals and their durability can be understood in the context of a short or long carbon cycle. Short-cycle removals manage carbon flows within the biosphere, such as through afforestation, soil carbon sequestration, and wetland restoration, where carbon is stored for years or decades. Long-cycle removals permanently remove carbon from the atmosphere and store it in geological formations or mineralized forms for thousands to millions of years.[113]

80. Academia and research organizations have an important role in educating the public on the viability and applicability of CDR approaches. For example, C2ES has defined technical and economic cost criteria for assessing the roles for different CDR approaches that can inform the design and implementation of carbon removal strategies. These include:
    - removal potential (megatons/year or gigatons stored by a given date)
    - economic costs (U.S. dollars/tonne)
    - durability or permanence
    - level of readiness (in consideration of the time value of carbon)
    - scalability
    - sink saturation.[114]

81. For example, while nature-based CDR approaches are cheaper and more readily available in the short term, engineered CDR can bring many advantages in addressing the climate crisis, including larger removal potentials, more durable carbon sequestration, greater scalability, and more locational flexibility.[115]

82. The figure below from "The State of Carbon Dioxide Removal" helpfully provides a visual representation of the kinds of CDR approaches and their main technical and economic cost characteristics.[116]



Stephen M. Smith et al, "The State of Carbon Dioxide Removal," 1, Figure 1.4 (2024), https://osf.io/69fvx.

83. The technical and cost elements presented above are not enough to determine the fitness or suitability of a CDR approach for specific geographies. Critically, what makes different CDR approaches viable in some regions more than others is the interplay of economic, ecologic, and policy enablers. Understanding the advantages and disadvantages of each CDR approach in light of these enablers is important when assessing the potential for a country's comparative advantage in the development and deployment of each. There are regional and local needs linked to the availability of natural resources, clean energy potential of existing infrastructure, and land use and SDG tradeoffs that need to be considered, especially for durable carbon removals. For example, BECCS requires both industrial infrastructure and land management capacity for its viability.[117]

84. The potential to integrate CDR across different sectors by leveraging existing infrastructure, industries, and ecosystems can potentially lower costs and deliver broader economic, environmental, and social co-benefits, many of which align closely with the SDGs. These include enhanced soil health, biodiversity restoration, and economic development. For example, geographic areas where industrial infrastructure and renewable sources of energy are abundant may have a competitive advantage in

developing energy intensive DACCS plants. Existing forest areas that are sustainably managed may have potential for BECCS. Places with large swaths of deforested land may be suitable for afforestation. IDDRI has called for the IPCC to take the lead on building mitigation pathway scenarios that consider the sustainability risks of deployment and do not cross sustainability thresholds.[118] These calls also encourage minimizing deployment of CDR methods with land-use change and establishing safeguards for land-based CDR.[119]

Annex III: Existing Efforts to Enhance CDR Accounting and Scenarios for Progress Tracking

85. Different efforts are underway to address CDR accounting—quantification and reporting—challenges. At COP26, Parties adopted methodologies and common metrics for reporting all greenhouse gas emissions and removals under the Enhanced Transparency Framework (ETF). Parties agreed to use the IPCC Guidelines, including the 2019 Refinement to the 2006 IPCC Guidelines on a voluntary basis, for the development of their national greenhouse gas inventories. The IPCC does not provide removal factors and sequestration rates to calculate removals across sectors covered,[120] so Parties are requested to report the methodologies used for estimating potential leakage of emissions from geological storage reservoirs as well as reversals due to forest fires or logging, for example.[121] Not all anthropogenic sources and sinks need to be accounted for in NDCs.[122] The upcoming IPCC Methodology Report on CDR technologies and carbon capture, utilization, and storage will provide an opportunity to expand guidelines for novel CDR approaches and lay the foundations for more comprehensive CDR quantification and reporting under the UNFCCC.[123]

86. In the context of Article 6 of the Paris Agreement, CDR gained more attention when experts from the Article 6.4 Supervisory Body released an informational note about the uncertainties of novel removal approaches in 2023.[124] In terms of accounting, safeguards, and sustainability considerations, at COP29 Parties adopted the Paris Agreement Crediting Mechanism (Article 6.4) Supervisory Body's methodology standards for use in international carbon markets,[125] which outline integrity criteria for carrying out mitigation activities, including for sustainability and carbon lock-in safeguards.[126] The removals standard addresses permanence (the amount of time carbon remains sequestered in sinks) as it links to the risk of reversals, provides removal MRV guidance, and includes considerations for avoiding leakage (emissions displacement) and social and environmental impacts.[127] For Article 6-eligible project categories, including CDR, specific crediting methodologies remain to be developed.[128]

87. In the broader UNFCCC ecosystem, the Mission Innovation (MI) CDR Mission has provided insights and recommendations on how to enhance MRV for CDR, based on international and domestic best practice, including as related to carbon markets, toward international harmonization of methodologies.[129]

88. Different modelling exercises have drawn scenarios for CDR deployment as part of global mitigation pathways. All IPCC global modelled pathways that limit warming to 1.5 degree C (greater than 50 percent) with no or limited overshoot, and those that limit warming to 2 degrees C (greater than 67 percent), involve rapid and deep and, in most cases, immediate greenhouse gas emissions reductions in all sectors this decade. In IPCC pathways that limit warming to 1.5 degrees C with no or limited overshoot, global use of coal falls by 95 percent by 2050, oil by about 60 percent, and gas by about 45 percent, assuming significant use of abatement technologies involving CCS. Without CCS technologies to achieve both emissions reductions and CDR, coal, oil, and gas pathways show much steeper

declines, with global use of coal virtually phased out by 2050.[130] The latest IPCC Working Group III report estimates upper technical mitigation potential of different CDR activities but does not prescribe specific pathways for CDR.[131] The IPCC notes that "while national mitigation portfolios aiming at net zero or net-negative emissions will need to include some level of CDR, the choice of methods and the scale and timing of their deployment will depend on the ambition for gross emissions reductions, how sustainability and feasibility constraints are managed, and how political preferences and social acceptability evolve."[132]

89. In the 2023 update to its Net Zero Roadmaps report 2023 update, the International Energy Agency (IEA) indicates that in a net-zero-by-2050 scenario (NZE), use of fossil fuels fall from almost 80 percent of total energy supply in 2022 to slightly over 20 percent by 2050.[133] Remaining fossil fuel use by 2050 is for goods where carbon is embodied in the product, such as plastics, in facilities equipped with CCUS, and in sectors where low-emissions technology options are scarce.[134] The IEA also shows that delaying action on emissions reductions (in a "Delayed Action Case" scenario that exceeds 1.6 degrees C for about 25 years and 1.5 degrees C for almost 50 years) would require substantial scaleup of CDR through BECCS and DACCS. Research coincides that heavier reliance on CDR would lead to a significant increase in energy use, economic costs, and resource use, relative a NZE scenario.[135]

90. For a 1.5 degrees C-aligned pathway, UNEP's Emissions Gap Report 2024 estimates that, by 2030, afforestation and reforestation removals would need to scale to 2.6 $GtCO_2e$ removed/year, and removals from improved forest management to 1.5 $GtCO_2e$/year. Aggregated removals in the agriculture sector, including biochar and enhanced soil management, would amount to 1.4 $GtCO_2e$/year.[136]

Annex IV: Examples of Effective Policies and Programs for CDR Development and Deployment

91. Clear policy frameworks and programs are fundamental to create the market incentives to scale use of CDR approaches.[137] On the supply side, these policies and programs:
    - stimulate innovation through CDR pilot prizes[138]
    - increase public funding for R&D up to commercial deployment, scaling support based on the readiness of different CDR methods
    - allocate dedicated resources to afforestation and reforestation efforts, fostering strategic partnerships with local communities
    - reduce CDR investment costs via tax credits and reduce transaction costs by responsible streamlining of permits (for example, the U.S. Inflation Reduction Act includes tax incentives for BECCS and DACCS, and a recent bill could expand the scope of eligible CDR approaches)[139]
    - establish CDR MRV and certification frameworks, including as part of carbon pricing policy involving the use of carbon removal credit (for example, the EU Carbon Removals and Carbon Farming Certification (CRCF) Regulation is the first public policy to certify technology and nature-based CDR units, including carbon storage in long-lasting products).[140]

92. On the demand side, policies and programs:
    - support different cases for carbon removal certificates or credits to be used by corporates and sovereign buyers toward compliance or achievement of voluntary climate goals. The CRCF, for example, is in the process of linking to the EU Emission Trading System (ETS) and the EU Green Claims Directive[141]

- launch public procurement tenders for CDR projects and related infrastructure to stimulate the market value of CDR products and services, enhancing the transparency of this data (since offers are publicly disclosed) while ensuring the intellectual property of innovations is protected[142]
- develop flexible price guarantees for sellers, such as "contracts for difference," first implemented by the UK,[143] whereby governments make up for any difference in the projected price of removal certificates (or credits) traded; or take-off agreements as a promise to purchase large amounts of CDR units at a specific price in the future, provided the expected results are delivered.[144]

93. As CDR is a relatively novel area for climate solutions research, leadership from NPS has been important in guiding CDR activities and their use toward climate goals, both by governments and NPS. Voluntary frameworks have informed the development of science-based strategies, including through the use of market-based approaches such as carbon credits. For example, the Science Based Targets initiative (SBTi) has led the development of the Corporate Net Zero Standard, with a recent revision requiring companies to progressively increase removals to match residual emissions at net zero, following a removal growth target method to be defined.[145] The Oxford principles specifically urge that organizations targeting net zero with the use of carbon credits will need to purchase 100 percent carbon removal credits by the global net-zero date (2050 at the latest).[146] The Integrity Council for the Voluntary Carbon Market (IC-VCM) has carried out a continuous improvement work program to explore further integrity requirements regarding permanence of removal credits.[147]

94. Leadership from NPS has also been valuable in keeping up on market trends, signaling investment and financing opportunities, and catalyzing government support, including at the sub-national level. NPS play important roles through private investor coalitions (e.g., Frontier), civil society initiatives (e.g., Counteract and Rethinking removals),[148] and city coalitions (e.g., 4 Corners Carbon Removal Coalition).[149] Market analysis and research organizations (e.g., CDR.fyi and Sylvera) quickly disseminate information for greater transparency on CDR trends to the broader climate ecosystem.[150]

References

[1] United Nations Framework Convention on Climate Change [hereinafter UNFCCC], *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 79 (December 13, 2023), https://unfccc.int/documents/637073.

[2] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 170. See also, UNFCCC, *Paris Agreement*, Art. 4.9, conclusion date: December 12, 2015, United Nations Treaty Series Online, registration no. I-54113, https://unfccc.int/sites/default/files/english_paris_agreement.pdf; UNFCCC, *Adoption of the Paris Agreement*, 1/CP.21, ¶¶ 22-25 (January 29, 2016), https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf#page=2; UNFCCC, *Common time frames for nationally determined contributions referred to in Article 4, paragraph 10, of the Paris Agreement*, Decision 6/CMA.3, ¶ 2 (March 8 2022), https://unfccc.int/sites/default/files/resource/CMA2021_10_Add3_E.pdf (Encourages Parties to communicate in 2025 a nationally determined contribution with an end date of 2035, in 2030 a nationally determined contribution with an end date of 2040, and so forth every five years thereafter); UNFCCC, *Report on the 11th meeting of the Paris Agreement Implementation and Compliance Meeting*, PAICC/2024/M11/4 (April 17-19, 2024), ¶ 19, https://unfccc.int/sites/default/files/resource/PAICC_11_meeting_report.pdf.

[3] *Features and Normative Requirements for Nationally Determined Contributions* (Arlington, VA: Center for Climate and Energy Solutions [hereinafter C2ES], June 2024), https://www.c2es.org/wp-content/uploads/2024/06/20240619-C2ES-NDC-Features-Normative-Requirements.pdf.

[4] UNFCCC, *Paris Agreement*, Arts. 3, 4.3. UNFCCC, *Further guidance in relation to the mitigation section of decision 1/CP.21*, Decision 4/CMA.1, Annex I, ¶ 4(c) (March 19, 2019), https://unfccc.int/sites/default/files/resource/cma2018_3_add1_advance.pdf.
[5] UNFCCC, *Paris Agreement*, Art. 4.2.
[6] UNFCCC, *Paris Agreement*, Arts. 3, 4.3. UNFCCC, *Further guidance in relation to the mitigation section of decision 1/CP.21*, Decision 4/CMA.1, Annex I, ¶ 6.
[7] UNFCCC, *Paris Agreement*, Arts. 3, 4.3. UNFCCC, *Further guidance in relation to the mitigation section of decision* 1/CP.21, Decision 4/CMA.1, Annex I, ¶ 7.
[8] UNFCCC, *Further guidance in relation to the mitigation section of decision 1/CP.21*, Decision 4/CMA.1, Annex I, ¶ 4(c).
[9] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 39.
[10] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 6.
[11] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 171.
[12] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 179.
[13]UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 28(e) (Accelerating zero- and low-emission technologies, including, inter alia, renewables, nuclear, abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production).
[14] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 33,(Further emphasizes the importance of conserving, protecting and restoring nature and ecosystems toward achieving the Paris Agreement temperature goal, including through enhanced efforts toward halting and reversing deforestation and forest degradation by 2030, and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases and by conserving biodiversity, while ensuring social and environmental safeguards, in line with the Kunming-Montreal Global Biodiversity Framework).
[15] CDR as mitigation encompasses different approaches in different sectors. In this paper, C2ES takes a cross-sectoral perspective, drawing from two signals: paragraph 28, the "energy package" section of the COP28 GST outcome, paragraph 28 sub-paragraph e, taken as technological approaches to CDR, and paragraph 33, taken as nature-based CDR, given its dependence on natural carbon sinks and linkage to biodiversity conservation.
[16] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 28(e) ([…]abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors[…]).
[17] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 33 ([…]reversing deforestation and forest degradation by 2030, and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases[…]).
[18] Hoesung Lee et al., *Climate Change 2023 Synthesis Report Summary for Policymakers,* 20-23 (Geneva, Switzerland: IPCC, 2023), https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf.
[19] See, e.g., Kaveh Guilanpour et al., *A Solutions-oriented Approach to the Paris Agreement's Global Stocktake* (Arlington, VA: C2ES, November 2023), https://www.c2es.org/document/a-solutions-oriented-approach-to-the-paris-agreements-global-stocktake/; UNFCCC, *Technical dialogue of the first global stocktake: Synthesis report by the co-facilitators on the technical dialogue* (September 8, 2023), https://unfccc.int/sites/default/files/resource/sb2023_09E.pdf; United Nations Climate Change High-Level Champions [hereinafter HLCs], and the Marrakech Partnership for Global Climate Action, *2030 Climate Solutions: Implementation Roadmap* (Bonn, Germany: UNFCCC, December 2023), https://www.climatechampions.net/frameworks/2030-climate-solutions/.
[20] Joanna Gill, "Energy efficiency: the net zero no brainer that has come of age," *Context*, January 19, 2024, https://www.context.news/net-zero/energy-efficiency-the-net-zero-no-brainer-that-has-come-of-age?utm_source=newsletter&utm_medium=email&utm_campaign=context-climate.
[21]Angel Galan-Martin et al., *Delaying carbon dioxide removal in the European Union puts climate targets at risk* (Nat Commun, November 11, 2021), 12, doi: 10.1038/s41467-021-26680-3.
[22] Mahmoud Abouelnaga, *Engineered Carbon Dioxide Removal: Scalability and Durability* (Arlington, VA: C2ES, October 2022), 2, 11, https://www.c2es.org/wp-content/uploads/2022/10/engineered-carbon-dioxide-removal-scalability-and-durability.pdf.

[23] Guilanpour et al., *A Solutions-oriented Approach to the Paris Agreement's Global Stocktake*.
[24] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶¶ 28, 33.
[25] The process of increasing commitment to climate action through the GST to inform climate action—including updating nationally determined contributions (NDCs) and national adaptation plans — is part of what is known as the Paris Agreement's "ambition cycle." It also includes the "enhanced transparency framework," the process for countries to gather and report greenhouse gas inventory data, track their progress against the overarching goals of the Paris Agreement and their own NDCs and deliver updates on the financial support they are providing or receiving. Parties are required to submit their first biennial transparency report (BTR1) and national inventory report by the end of December 2024.
[26] UNFCCC, *Paris Agreement*, Arts. 14.1, 14.2.
[27] UNFCCC, *Paris Agreement*, Art. 14.3.
[28] UNFCCC, *Outcome of the first global stocktake,* Decision 1/CMA.5, ¶¶ 9-10.
[29] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 170. See also, UNFCCC, *Paris Agreement*, Art. 4.9; UNFCCC, *Adoption of the Paris Agreement*, 1/CP.21, ¶¶ 22-25; UNFCCC, *Common time frames for nationally determined contributions referred to in Article 4, paragraph 10, of the Paris Agreement*, Decision 6/CMA.3, ¶ 2 (Encourages Parties to communicate in 2025 a NDC with an end date of 2035, in 2030 a NDC with an end date of 2040, and so forth every five years thereafter).
[30] Mustafa Babiker et al., "Cross-Chapter Box 8: Carbon Dioxide Removal: Key Characteristics and Multiple Roles in Mitigation Strategies, Chapter 12: Cross Sectoral Perspectives;" in *Climate Change 2022: Mitigation of Climate Change, Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva, Switzerland: IPCC, 2022), 1261-1262, https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf.
[31] While the number of countries setting net zero targets has levelled off, the proportion of these targets formalized into law or official policy has steadily risen, covering 73 percent of global greenhouse emissions. Sybrig Smit et al., *Net-Zero Stocktake 2024* (Net Zero Tracker, September 2024), https://zerotracker.net/analysis/net-zero-stocktake-2024.
[32] UNFCCC, *2024 NDC Synthesis Report*, FCCC/PA/CMA/2024/10, ¶¶ 17, 64, 149 (October 28, 2024), https://unfccc.int/sites/default/files/resource/cma2024_10_adv.pdf.
[33] For example, in 2022 Finland became the first country to put a "net negative" emission climate target into law, to be achieved through domestically sourced removals from the Agriculture, Forestry, and Other Land Uses (AFOLU) sector. The law is based on the Finnish Climate Change Panel's recommendations. See, e.g., Ministry of Economic Affairs and Employment of Finland, *Carbon Neutral Finland 2035 – National Climate and Energy Strategy*, (2022), https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164323/TEM_2022_55.pdf?sequence=4&isAllowed=y; "Carbon Neutral Finland 2035," *State Treasury Republic of* Finland, accessed April 24, 2025, https://www.treasuryfinland.fi/investor-relations/sustainability-and-finnish-government-bonds/carbon-neutral-finland-2035/.
[34] In 22 percent of countries' LT-LEDS, the mitigation goal cannot be classified as net zero greenhouse gas or net zero carbon dioxide emissions, and 18 percent of countries' LT-LEDS do not refer to a concept related to net zero emissions by a certain date and instead describe absolute emission reduction levels compared with a base-year level or policies and actions without a quantifiable long-term mitigation goal. UNFCCC, *Long-term low emission development strategies*, ¶ 10, (November 14, 2023), https://unfccc.int/sites/default/files/resource/cma2023_10.pdf.
[35] UNFCCC, *Long-term low emission development strategies*, ¶¶ 84, 111 (November 14, 2023).
[36] UNFCCC, *Glasgow Climate Pact*, Decision 1/CMA.3, ¶ 30 (March 8, 2022), https://unfccc.int/sites/default/files/resource/cma2021_10a01E.pdf.
[37] Hoesung Lee et al., *Climate Change 2023 Synthesis Report Summary for Policymakers,* 20-23 (Geneva, Switzerland: IPCC, 2023), https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf.
[38] Carl Friedrich Schleussner, et al*., Overconfidence in climate overshoot*, Nature 634, (October 9, 2024), 366–373, https://doi.org/10.1038/s41586-024-08020-9.

[39] *Delivering on the Targets and Signals from the First Global Stocktake* (Arlington, VA: C2ES, October 2024), https://www.c2es.org/wp-content/uploads/2024/10/Delivering-on-the-Targets-and-Signals-from-the-First-Global-Stocktake.pdf.
[40] "Ministry of Investment Launches Whitepaper Showcasing the UAE's Fit for Purpose Platform and Vision for Future Growth," *United Arab Emirates Ministry of Investment*, January 24, 2025, https://www.investuae.gov.ae/announcement/ministry-of-investment-launches-whitepaper-showcasing-the-uaes-fit-for-purpose-platform-and-vision-for-future-growth.
[41] United Arab Emirates' Ministry of Climate Change and Environment, *The United Arab Emirates' Third Nationally Determined Contribution (NDC 3.0) Accelerating Action Towards Mission 1.5C* (UNFCCC, November 2024), https://unfccc.int/sites/default/files/2024-11/UAE-NDC3.0.pdf.
[42] See e.g., "EBRD approves new country strategy for Azerbaijan," Rezo Bitsadze, European Bank for Reconstruction and Development, January 31, 2025, https://www.ebrd.com/home/news-and-events/news/2025/EBRD-approves-new-country-strategy-for-Azerbaijan.html; Azerbaijan Country Strategy, EBRD, January 29, 2025, https://www.ebrd.com/azerbaijan-strategy-2025-2030.pdf; "Brazil Launches National Bioeconomy Strategy,"Serhat Demirkol, Brazilian NR, June 9, 2024, https://braziliannr.com/2024/06/09/brazil-launches-national-bioeconomy-strategy/#:~:text=This%20involves%20investing%20in%20research,markets%20for%20bio%2Dbased%20products; "The Bioeconomy in Lula Administration: Regulatory and Institutional Advances," Cristina Leme Lopez et al., Climate Policy Initiative, November 11, 2024, https://www.climatepolicyinitiative.org/publication/the-bioeconomy-in-the-lula-administration-regulatory-and-institutional-advances/.
[43] Brenda Silveira et al., *Bioenergy with Carbon Capture and Storage BECCS in Brazil: a Review*, (February 17, 2023) https://www.mdpi.com/1996-1073/16/4/2021.
[44] "This is CDR: Tropical Scale, Global Impact – NetZero's Bold Biochar Vision for Brazil," OpenAir, April 15, 2025, https://lu.ma/a9ds7z4y?tk=6eYccf.
[45] Brazilian Government, *Brazil's NDC: National determination to contribute and transform,* (*November 13, 2024*), 15, 16, 30, https://unfccc.int/sites/default/files/2024-11/Brazil_Secondpercent20Nationallypercent20Determinedpercent20Contributionpercent20percent28NDCpercent29_November2024.pdf.
[46] Stephen M. Smith et al., *The State of Carbon Dioxide Removal 2024 - 2nd Edition* (University of Oxford's Smith School of Enterprise and the Environment, 2024), https://osf.io/f85qj/.
[47] "We are recruiting!," The State of Carbon Dioxide Removal, accessed May 15, 2025, www.stateofcdr.org.
[48] International Energy Agency [hereinafter IEA], "What's on Track?" in *Tracking Clean Energy Progress 2023* (July 2023), https://www.iea.org/reports/tracking-clean-energy-progress-2023.
[49] "Tracking Bioenergy with Carbon Capture and Storage," *IEA*, accessed April 15, 2025, https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage/bioenergy-with-carbon-capture-and-storage#tracking.
[50] "Tracking Direct Air Capture," IEA, accessed April 15, 2025, https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage/direct-air-capture#tracking.
[51] "Tracking Carbon Capture, Utilisation and Storage," *IEA*, accessed April 15, 2025, https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage.
[52] Mathilde Fajardy et al., "CCUS projects around the world are reaching new milestones," IEA, April 30, 2025, https://www.iea.org/commentaries/ccus-projects-around-the-world-are-reaching-new-milestones.
[53] UNEP, *Emissions Gap Report 2024*, Appendices - No more hot air … please, Appendix E, 52 (October 2024) https://wedocs.unep.org/20.500.11822/46381.
[54] "2030 Breakthroughs," *UN High-Level Champions*, https://www.climatechampions.net/frameworks/breakthroughs/. See also "Industry," "Nature," and "Oceans and Coastal Zones."
[55] Raimi et al., *Global Energy Outlook 2024: Peaks or Plateaus?* (Washington, DC: Resources for the Future, April 2024), 3, https://www.rff.org/publications/reports/global-energy-outlook-2024/.

[56] Lorenzo Sani, "Curb Your Enthusiasm: Bridging the gap between the UK's CCUS targets and reality," *Carbon Tracker Initiative* (March 13, 2024), https://carbontracker.org/reports/curb-your-enthusiasm/; Lena Faber et al., *A Trojan horse for climate policy: Assessing carbon lock-ins through the Carbon Capture and Storage-Hydrogen-Nexus in Europe*, (Energy Research and Social Science, 2025), https://www.sciencedirect.com/science/article/pii/S2214629624004729?viapercent3Dihub; Megren Almutairi and Karen E. Young, "How Carbon Capture Technology Could Maintain Gulf States' Oil Legacy," *Center for Global and Energy Policy at Columbia SIPA*, February 19, 2024, https://www.energypolicy.columbia.edu/how-carbon-capture-technology-could-maintain-gulf-states-oil-legacy/#:~:text=Saudipercent20Arabiapercent20aimspercent20topercent20increase,percent5B16percent5D.

[57] Madeleine Luck et al., *Carbon Dioxide Removal (CDR) Evidence Review: An overview of CDR and bottlenecks to overcome*, (Quadrature Climate Foundation, January 2024), 4, https://www.qc.foundation/files/press/Carbon-dioxide-removal.pdf.

[58] Guilanpour et al., *A Solutions-oriented Approach to the Paris Agreement's Global Stocktake*; Lavanya Rajamani et al., *Re-invigorating the UN Climate Regime in the Wider Landscape of Climate Action* (Arlington, VA: C2ES, November 2023), https://www.c2es.org/document/re-invigorating-the-un-climate-regime/.

[59] UNFCCC, *Technical dialogue of the first global stocktake: Synthesis report by the co-facilitators on the technical dialogue*.

[60] See e.g., Ángel Galán-Martín, et al., *Delaying carbon dioxide removal in the European Union puts climate targets at risk*, Nature Communications (November 11, 2021), Volume 12, 6490, doi: 10.1038/s41467-021-26680-3.

[61] Mahmoud Abouelnaga (Arlington, VA: C2ES, 2022), https://www.c2es.org/wp-content/uploads/2022/10/engineered-carbon-dioxide-removal-scalability-and-durability.pdf.

[62] Guilanpour et al., *A Solutions-oriented Approach to the Paris Agreement's Global Stocktake*.

[63] According to IEA, in 2023 governments spent U.S. $620 billion to subsidize the use of fossil fuels, particularly in emerging and developing economies. This figure dwarfs the U.S. $70 billion that was spent in 2023 to support clean energy investments, in the form of grants, rebates for electric vehicles, and initiatives to enable energy efficiency improvements. *Strategies for Affordable and Fair Clean Energy Transitions* (Paris, France: IEA, May 2024), https://www.iea.org/reports/strategies-for-affordable-and-fair-clean-energy-transitions.

[64] However, the overall balance is overwhelmingly positive in terms of achieving SDGs and climate action. See *Synergy Solutions for Climate and SDG Action: Bridging the Ambition Gap for the Future We Want Report on Strengthening the Evidence Base* (United Nations, 2024), https://sdgs.un.org/sites/default/files/2024-07/UNpercent20Synergypercent20Solutionspercent20forpercent20Climatepercent20andpercent20SDGpercent20Action-3.pdf. See also, Måns Nilsson et al., *Seeking Synergy Solutions Policies that Support Both Climate and SDG Action* (Expert Group on Climate and SDG Synergy, 2024), https://sdgs.un.org/sites/default/files/2024-06/Thematicpercent20Reportpercent20onpercent20Climatepercent20andpercent20SDGspercent20Action-060824.pdf.

[65] Guilanpour et al., *A Solutions-oriented Approach to the Paris Agreement's Global Stocktake;* HLCs and the Marrakech Partnership for Global Climate Action, *2030 Climate Solutions: Implementation Roadmap,* Technology-Based Carbon Removals, ¶ 40.

[66] A carbon price applied to emissions of regulated entities represents an added production cost which is often transferred onto consumers through a price increase in final products sold to the market.

[67] C2ES internal presentation for the 2025 Global Direct Air Capture Conference, Direct Air Capture Coalition (17-18 March), https://web.cvent.com/event/f0b0bd9e-54cf-48bc-8151-011ddc95ce22/summary, adapted from Innovation Technology and Innovation Foundation.

[68] The HLCs' initiatives and analytical work are offered as valuable resources to Parties in taking climate action. "Meet the Climate High-Level Champions," UNFCCC, accessed May 16, 2025, https://unfccc.int/climate-action/engagement/marrakech-partnership-for-global-climate-action/actors/meet-the-climate-high-level-champions.

[69] HLCs and the Marrakech Partnership for Global Climate Action, *2030 Climate Solutions: Implementation Roadmap*.

[70] These actions and enablers have been drawn from the HLCs work on the 2030 Breakthroughs, which sets out a Clean Power Breakthrough aiming for solar and wind to make up at least 40 percent – and all renewables to make up at least 60 percent – of global electricity generation by 2030. "2030 Breakthroughs," UNFCCC, accessed 16, , https://climatechampions.unfccc.int/system/breakthroughs/. They also draw on the Breakthrough Agenda; it aims to make clean power "the most affordable and reliable option for all countries to meet their power needs efficiently by 2030." "The Breakthrough Agenda," accessed May 16, 2025, https://breakthroughagenda.org/.
[71] Guilanpour et al., *A Solutions-oriented Approach to the Paris Agreement's Global Stocktake*, 38.
[72] "Carbon Dioxide Removal Mission," Mission Innovation, accessed 14 May 2025, https://explore.mission-innovation.net/mission/carbon-dioxide-removal/.
[73] "Carbon Capture, Utilization and Storage," *Clean Energy Ministerial*, accessed May 13, 2025, https://www.cleanenergyministerial.org/initiatives-campaigns/carbon-capture-utilization-and-storage/.
[74] Australia, Canada, Egypt, Norway, Denmark, Japan, Saudi Arabia, the European Union, the United Arab Emirates, and the United States of America launched the Carbon Management Challenge at the Major Economies Forum in April 2023. "About," *Carbon Management Challenge*, https://www.carbonmanagementchallenge.org/.
[75] Kenya, Indonesia and the US co-lead the Developing Country Project Finance workstream; Brazil, the Project Deployment and Tracking; Saudi Arabia and the UK, Communications and Engagement. "CMC Governance Structure," Carbon Management Challenge, February 11, 2025, https://www.carbonmanagementchallenge.org/resources/cmc-governance-structure.
[76] "COP28: Tracking the Energy Outcomes," IEA, accessed September 16, 2024, https://www.iea.org/topics/cop28-tracking-the-energy-outcomes?utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top. (This website comes in response to the G7 Climate, Energy and Environment Ministers, who, in its April 2024 communique, reaffirmed the global need to transition away from fossil fuels and called upon IEA to provide recommendations in 2025 to decision makers on how to design a roadmap to implement the transition away from fossil fuels in energy systems, including the technology pathways and timeframes to enable this transition, including to enable reduction in fossil fuels demand and to provide detailed tracking of its progress.)
[77] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶ 28.
[78] Martina Lyons, et al., *Reaching Zero with Renewables: Capturing Carbon*, Technical paper 4, October 2021, https://www.irena.org/-/media/Irena/Files/Technical-papers/IRENA_Capturing_Carbon_2021.pdf.
[79] "Canada Invests More Than $9.5M In Innovative Carbon Management Technologies," Sasha Ranevska, Carbon Herald, February 18, 2025, https://carbonherald.com/canada-invests-more-than-9-5m-in-innovative-carbon-management-technologies/.
[80] Sarah Thompson and Damien Steel, "Could Canada be a global leader in the carbon removal industry?," *Capital Markets*, February 12, 2025, https://www.rbccm.com/en/story/story.page?dcr=templatedata/article/story/data/2025/01/energy-needs-scaling-demands-and-carbon-capture-in-canada.
[81] "Keep calm and Remove On: 2024 year in review," *Cdr.fyi*, February 14, 2025, https://www.cdr.fyi/blog/2024-year-in-review.
[82] Stefan Frank et al., *Enhanced agricultural carbon sinks provide benefits for farmers and the climate*, Nature Food, Volume 5, September 23, 2024, Figure 3, 746, https://doi.org/10.1038/s43016-024-01039-1;
Carbon Capture, Utilization and Storage (CCUS) Technology Gaps and International Collaboration, G20 ETWG Presidency, February 2023, https://www.g20.in/content/dam/gtwenty/gtwenty_new/document/etwg_docu/14_G20percent20ETWGpercent20Presidencypercent20Documentpercent20-Studypercent20onpercent20Carbonpercent20Capturepercent20Utilizationpercent20_percent20Storagepercent20(CCUS)percent20Technologypercent20Gapspercent20_percent20Internationalpercent20Collaboration.pdf.
[83] "Sherpa Track," *G20 South Africa 2025*, accessed April 27, 2025, https://g20.org/tracks/sherpa-track/.
[84] "Climate Promise," UNDP, accessed May 16, 2025, https://climatepromise.undp.org.
[85] "UN Development Programme launches next phase of flagship climate action initiative" (Press Release), *UNDP*, April 23, 2024, https://climatepromise.undp.org/news-and-stories/un-development-programme-launches-next-

phase-flagship-climate-action-initiative. "Climate Promise 2025," UNDP, accessed May 15, 2025, https://climatepromise.undp.org/what-we-do/flagship-initiatives/climate-promise-2025.

[86] "About Us," NDC Partnership, accessed May 16, 2025, https://ndcpartnership.org/about-us.

[87] "NDC 3.0 Navigator," NDC Partnership, accessed September 16, 2024, https://ndcnavigator.org/.

[88] "Route: Technology and Capacity-Building as Needs and Enablers," NDC Navigator, About this Route, Reflecting the Global Stocktake, accessed May 13, 2025, https://ndcnavigator.org/routes/technology-and-capacity-building/. (The NDC Navigator 3.0 refers to the first Global Stocktake in those paragraphs that highlight the need for capacity-building and technology transfer to improve the implementation of NDCs).

[89] Noora Al Amer, *Carbon Management in NDCs: a collation, assessment and a path forward*, 2024 Thought Leadership (Global CCS Institute, December 2024), 11, https://www.globalccsinstitute.com/wp-content/uploads/2024/12/Carbon-management-in-NDCs-Report.pdf.

[90] Technology Executive Committee, *Integrating hard-to-abate industries in the process of preparing and implementing NDCs*, Brief #19 (UNFCCC and United Nations Industrial Development Organization: 2024), 2, 7, 9, 2024, https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEC_documents/bb257f9ab28c416cbf76e6a75ba82875/e3dbe77ca6594d9c942eaac82320e693.pdf. Also, "Action to Decarbonize High Emitting Industrial Sectors Gathers Pace – Key Steps by the Technology Executive Committee," *UNFCCC*, May 6, 2024, https://unfccc.int/news/action-to-decarbonize-high-emitting-industrial-sectors-gathers-pace-key-steps-by-the-technology.

[91] UNFCCC, *Outcome of the first global stocktake*, Decision 1/CMA.5, ¶¶ 28, 33.

[92] William F. Lamb et al., *Countries need to provide clarity on the role of carbon dioxide removal in their climate pledges*, Environmental Research Letters, Volume 19, Number 12 (November 22, 2024), 3, https://iopscience.iop.org/article/10.1088/1748-9326/ad91c7.

[93] "How Separate Climate Targets Can Help Avoid Overreliance on Carbon Removal," Katie Lebling et al., World Resources Institute (WRI), August 6, 2024, https://www.wri.org/technical-perspectives/separate-climate-targets-carbon-dioxide-removal.

[94] "Joint Multilateral Development Banks Long-Term Strategy Program (LTS-P)," World Bank, https://thedocs.worldbank.org/en/doc/5ede0588723ff3bdb3a4d1e319f18fc5-0320052024/original/Primer-MDB-LTS-Program-Web.pdf (prepared for COP29 side event "MDBs' Long-Term Strategies Program (LTS-P): Moving from Launch to Delivery" held November 14, 2024, https://www.adb.org/cop/cop29/mdbs-long-term-strategies-program).

[95] Unlike previous estimates, recent market research has shown that most durable CDR projects would "break even" and be financially profitable at a marginal abatement cost well above 100USD/tCO2eq. Suppliers indicated a "breakeven" sale price range of $140-$340/mt, while the range suppliers said they needed for "a reasonable profit" was $180-$430/mt. *2025 CDR Market Survey, In Net Zero Standards We Trust* (Sylvera and CDR.fyi, March 5, 2025), 9, https://www.sylvera.com/blog/2025-cdr-market-survey-key-findings.

[96] Hollie Jean Buck, et al., "Why residual emissions matter right now," in *Nature Climate Change,* vol. 13 (March 9, 2023), 351–358, https://doi.org/10.1038/s41558-022-01592-2; Alexandra Deprez et al., "Sustainability limits needed for CO_2 removal," in *Science*, vol. 383, Issue 6682, (February 1, 2024), 484-486, DOI: 10.1126/science.adj6171.

[97] See, e.g., "Curb Your Enthusiasm: Bridging the gap between the UK's CCUS targets and reality," Lorenzo Sani, Climate Tracker Initiative, 13 March, 2024, https://carbontracker.org/reports/curb-your-enthusiasm/; Lena Faber et al., *A Trojan horse for climate policy: Assessing carbon lock-ins through the Carbon Capture and Storage-Hydrogen-Nexus in Europe*, Energy Research and Social Science, Volume 120, https://doi.org/10.1016/j.erss.2024.103881; "How Carbon Capture Technology Could Maintain Gulf States' Oil Legacy," Megren Almutairi and Karen E. Young, Center on Global Energy Policy at Columbia SIPA, February 19, 2024, https://www.energypolicy.columbia.edu/how-carbon-capture-technology-could-maintain-gulf-states-oil-legacy/.

[98] Studies reveal a misalignment between scientific estimates of land carbon uptake and official national greenhouse gas inventories on the basis of NDCs. Different definitions of anthropogenic carbon dioxide

fluctuations in managed forests or estimates of deforestation and organic soils can result in overestimating land-based carbon removals, implying the need for greater emissions reduction targets in NDCs. Kim Koetzee et al., *Addressing challenges in the land sector of the Paris Agreement* (Berlin: Climate Analytics, March 2025), 3, 26, https://ca1-clm.edcdn.com/publications/Addressing-challenges-in-the-land-sector-under-the-Paris-Agreement.pdf?v=1745423052.

[99] Mahmoud Abouelnaga, *Engineered Carbon Dioxide Removal: Scalability and durability,* 11.

[100] Sean Low et al., *Public perceptions on carbon removal from focus groups in 22 countries*, Nature Communications, Volume 15, April 24, 2024, https://pmc.ncbi.nlm.nih.gov/articles/PMC11043362/.

[101] "About Us," Great Carbon Valley, accessed March 31, 2025, https://www.greatcarbonvalley.com/about-us.

[102] The Mitigation Work Programme (MWP) has provided spaces for best practice exchange on pathways to net zero through dialogues and investment focused events carried out since COP27. Accelerating CDR implementation has not been a specific topic of MWP mandated dialogues but covered as relevant in presentations. The first dialogue included discussions on CCUS. The fifth dialogue (May 2025) addressed mitigation solutions in the forest sector, likely covering CDR afforestation and reforestation approaches. See UNFCCC, "Sharm el-Sheikh mitigation ambition and implementation work program, Annual Reports," https://unfccc.int/topics/mitigation/workstreams/mitigation-work-programme; *Sharm el-Sheikh mitigation ambition and implementation work programme. Annual report by the secretariat*, FCCC/SB/2024/5, October 29, 2024, https://unfccc.int/sites/default/files/resource/sb2024_05.pdf; *Sharm el-Sheikh mitigation ambition and implementation work programme. Annual report by the secretariat*, FCCC/SB/2023/8, November 17, 2023, https://unfccc.int/sites/default/files/resource/sb2023_08.pdf; "Latest News," *Sharm el-Sheik Mitigation Work Programme*, UNFCCC, March 24, 2025, https://unfccc.int/topics/mitigation/workstreams/mitigation-work-programme.

[103] The JTWP has defined the elements to discuss pathways to achieving the goals of the Paris Agreement, with a view to informing the second global stocktake. These dialogues have yet to bring stakeholders together for best practice exchanges, including on CDR pathways. The third mandated dialogue will explore links with adaptation and resilience which could touch on co-benefits of some CDR solutions. See "Latest News," *United Arab Emirates Just Transition Work Programme*, UNFCCC, accessed May 15, 2025, https://unfccc.int/topics/just-transition/united-arab-emirates-just-transition-work-programme (The Chairs of the subsidiary bodies invite Parties, observers and other non-Party stakeholders to submit views on work to be undertaken under, as well as possible topics for the dialogues under the work programme in 2025 via the submission portal by February 15, 2025). See also "Climate Week May 2025," UNFCCC, accessed May 15, 2025, https://unfccc.int/topics/climate-weeks#2025.

[104] UNFCCC, *Draft Standard: Addressing leakage in mechanism methodologies*, V2.0, Article 6.4 Mechanism, (April 17, 2025), https://unfccc.int/sites/default/files/resource/A6.4-MEP005-A02.pdf.

[105] UNFCCC, *Glasgow Climate Pact*, Decision 1/CMA.3, ¶ 30.

[106] "Building Support for More Ambitious Climate Actions," UNFCCC, March 14, 2024, https://unfccc.int/news/building-support-for-more-ambitious-national-climate-action-plans.

[107] The Rhodium Group, for example, groups CDR approaches into three categories: natural, hybrid, and engineered solutions. Hybrid approaches include solutions that occur naturally but need human intervention to occur at a pace that would be meaningful for decarbonization. Whitney Jones, et al., *The Landscape of Carbon Dioxide Removal and US Policies to Scale Solutions* (Rhodium Group, April 10, 2024), 15, https://rhg.com/research/carbon-dioxide-removal-us-policy/.

[108] Babiker et al., "Cross-Chapter Box 8: Carbon Dioxide Removal: Key Characteristics and Multiple Roles in Mitigation Strategies."

[109] "The CCUS Hub," accessed April 27, 2025, https://ccushub.ogci.com/ccus-basics/understanding-ccus/.

[110] "What is carbon capture, usage and storage (CCUS) and what role can it play in tackling climate change?" London School of Economics, March 13, 2023, https://www.lse.ac.uk/granthaminstitute/explainers/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/; "What is carbon Management," Loans Program Office Tech Talk: Carbon Management, *U.S. Department of Energy*, accessed May 2, 2025, https://www.energy.gov/lpo/articles/lpo-tech-talk-carbon-management.

[111] Jonathan Foley, "To get back on track, we need new climate approaches," *Project Drawdown*, January 16, 2025, https://drawdown.org/insights/to-get-back-on-track-we-need-new-climate-leadership-and-approaches.
[112] Another short lived, high global warming potential agent is black carbon or soot. "Short-lived climate pollutants," C2ES, accessed May 1, 2025, https://www.c2es.org/content/short-lived-climate-pollutants/.
[113] Adam Whitmore and Mark Preston Aragonès, *Addressing differences in permanence of Carbon Dioxide Removal* (Oslo, Norway: Bellona Foundation: April 2022), 6, https://network.bellona.org/content/uploads/sites/3/2022/04/Addressing-differences-in-permanence-of-Carbon-Dioxide-Removal.pdf.
[114] "Carbon Dioxide Removal," C2ES, accessed March 17, 2025, https://www.c2es.org/content/carbon-dioxide-removal/.
[115] Mahmoud Abouelnaga, *Engineered Carbon Dioxide Removal: Scalability and Durability*, 2022.
[116] Stephen M. Smith et al., *The State of Carbon Dioxide Removal 2024*, 2nd Ed., 27.
[117] Gert-Jan Nabuurs et al., *Chapter 7: Agriculture, Forestry and Other Land Uses (AFOLU)* (UK and New York, USA: Cambridge University Press, 2022), https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter07.pdf, 831; in IPCC, *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.
[118] Alexandra Deprez et al., *Sustainability limits needed for CO_2 removal*.
[119] Alexandra Deprez, "Carbon dioxide removal: Five principles for a science-based, sustainable, and feasible approach," IDDRI, September 14, 2023, https://www.iddri.org/en/publications-and-events/billet-de-blog/carbon-dioxide-removal-five-principles-science-based.
[120] Sectors covered by IPCC guidelines are: energy; industrial processes and product use (IPPU); agriculture, forestry and land use (AFOLU); and waste. See different sector methodologies in "2006 IPCC Guidelines for National Greenhouse Gas Inventories," Task on National Greenhouse Gas Inventories, IPCC, accessed April 27, 2025, https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.
[121] María José Sanz Sánchez, et al., "Reporting Guidance and Tables," in *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Ch. 8, (IPCC, 2006), https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8_Ch8_Reporting_Guidance.pdf.
[122] UNFCCC, *Reference Manual for the Enhanced Transparency Framework under the Paris Agreement*, (Bonn, Germany: UNFCCC 2022), https://unfccc.int/sites/default/files/resource/v2_ETFreferencemanual.pdf.
[123] William F. Lamb et al., *Countries need to provide clarity on the role of carbon dioxide removal in their climate pledges*, Environmental Research Letters, 19, 121001, 3 (November 22, 2024), https://doi.org/10.1088/1748-9326/ad91c7 (referring to work underway by the IPCC's Task Force on National Greenhouse Gas Inventories 'Report of the IPCC Expert Meeting, *IPCC Expert Meeting Report on Carbon Dioxide Removal Technologies and Carbon Capture, Utilization and Storage*, 1-3 July 2024, Vienna, Austria (Hayama, Japan: Institute for Global Environmental Strategies, IGES), https://www.ipcc.ch/site/assets/uploads/2025/01/2407_CDR_CCUS_Report.pdf.)'
[124] UNFCCC, Removal activities under the Article 6.4 mechanism, Information note, Version 4.0, March 2023, https://unfccc.int/sites/default/files/resource/a64-sb005-aa-a09.pdf.
[125] Catalina Cecchi, "Why the COP29 Article 6 decision strengthens high-integrity carbon markets," C2ES, February 6, 2025, https://www.c2es.org/2025/02/why-the-cop29-article-6-decision-strengthens-high-integrity-carbon-markets/.
[126] "Core Carbon Principles," Integrity Council for the Voluntary Carbon Market [hereinafter: ICVCM], accessed April 27, 2024, https://icvcm.org/core-carbon-principles/.
[127] UNFCCC, *Removals standard, Article 6.4 Mechanism*, A6.4-SBM014-A06, v.1 (October 2024), https://unfccc.int/sites/default/files/resource/A6.4-SBM014-A06.pdf.
[128] Cecchi, "Why the COP29 Article 6 decision strengthens high-integrity carbon markets."
[129] Renee Birchall et. all, *Measurement, Reporting and Verification (MRV) for Carbon Dioxide Removal (CDR)*, (Ministry of Economy, Trade and Industry of Japan for the Mission Innovation for Carbon Dioxide Removal Mission,

December 2024), https://mission-innovation.net/wp-content/uploads/2024/12/2024-12_CDR-Mission-MRV-Report.pdf.
[130] Hoesung Lee et al., *Climate Change 2023 Synthesis Report Summary for Policymakers,* 20-21.
[131] Gert-Jan Nabuurs et al., *Chapter 7: Agriculture, Forestry and Other Land Uses (AFOLU),* https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter07.pdf, 831.
[132] Babiker et al., "Cross-Chapter Box 8: Carbon Dioxide Removal: Key Characteristics and Multiple Roles in Mitigation Strategies."
[133] *Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach* (Paris, France: IEA, 2023), 75, https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach.
[134] *Net Zero by 2050* (Paris, France: IEA, 2021), https://www.iea.org/reports/net-zero-by-2050.
[135] Neil Grant et al, *Confronting mitigation deterrence in low-carbon scenarios*, Environ. Res. Lett. 16 064099 (June 28, 2021), 9, DOI 10.1088/1748-9326/ac0749.
[136]*Emissions Gap Report 2024*, No more hot air…please!, Appendices (United Nations Environment Program [hereinafter: UNEP], October 2024), https://doi.org/10.59117/20.500.11822/46404.
[137] *CDR.fyi Market Insight: Winning Durable CDR Policy* (CDR.fyi, February 21, 2025), https://www.cdr.fyi/blog/cdr-fyi-insight-winning-durable-cdr-policy.
[138] "Next Generation NDCs: NDC Opportunities for Incorporating Technological Carbon Removal," WRI, accessed May 2, 2025, https://www.wri.org/ndcs/resources/technological-carbon-removal.
[139] The 45Q tax credit provides up to 180 U.S. dollars ($) per metric ton of carbon dioxide (tCO2) for geologic sequestration (CCS) and up to $130/tCO2 for utilization (CCUS). The Carbon Removal Investment Act, which was introduced in the 118th Congress, is a technology-neutral proposal that would create a new tax credit for carbon sequestration aimed at expanding the scope of incentives for broader CDR approaches. The bill proposes a credit of $250/tCO2 for all approaches except for BECCS, which would receive $110/tCO2. See "Carbon Dioxide Removal Investment Act," Katie Lebling et al., WRI, November 21, 2024, https://www.wri.org/update/carbon-dioxide-removal-investment-act.
[140] "Carbon Removals and Carbon Farming," EU Carbon Removals and Carbon Farming Certification (CRCF) Regulation, European Commission, accessed May 2, 2025, https://climate.ec.europa.eu/eu-action/carbon-removals-and-carbon-farming_en.
[141] "IETA's Recommendations for the Implementation of the EU Carbon Removals Carbon Farming Regulation," International Emissions Trading Association, February 6, 2025, https://www.ieta.org/ietas-recommendations-for-the-implementation-of-the-eu-carbon-removals-carbon-farming-regulation/.
[142] Chris Neidl et al., *Building a bridge to CDR Leadership in Luxembourg* (Openair: March 2025), 15-22, https://openaircollective.com/wp-content/uploads/2025/03/Policy-Proposal-Luxembourg-CDR-Leadership_2025.pdf.
[143] Nicole Watson and Paul Bolton, *Contracts for Difference Scheme*, Research Briefing (House of Commons Library, UK Parliament: October 14, 2024), https://commonslibrary.parliament.uk/research-briefings/cbp-9871/.
[144] "Offtake agreement template," Frontier Climate, August 15, 2024, https://frontierclimate.com/offtake-agreement-template.
[145] SBTi proposes that CDR are delivered through solutions that meet a minimum durability threshold. This threshold can be fixed (like-for-like) so as to match the global warming potential of each GHG type removed, or it can gradually increase over time (gradual transition) in line with the rate of deployment of a net zero removals portfolio. SBTi Corporate Net-Zero Standard, Version 2.0 – Initial Consultation Draft with Narrative (March 18, 2025), 65, https://sciencebasedtargets.org/resources/files/Net-Zero-Standard-v2-Consultation-Draft.pdf.
[146] Kaya Axelsson, et al., *Oxford Principles for Net Zero Aligned Carbon Offsetting (revised 2024)*, (Smith School of Enterprise and the Environment, University of Oxford, February 2024), 18-19, https://www.smithschool.ox.ac.uk/sites/default/files/2024-02/Oxford-Principles-for-Net-Zero-Aligned-Carbon-Offsetting-revised-2024.pdf.
[147] "Our Continuous Improvement Work Programs," ICVCM, accessed April 27, 2025, https://icvcm.org/continuous-improvement-work-programs/.

[148] Since its launch in 2022, Frontier has signed offtake agreements with 14 companies across four distinct carbon removal pathways, totaling $530 million. In addition to these offtakes with growth-stage companies, Frontier buyers have made pre-purchases from 34 early-stage companies, supporting their transition from the lab to real-world application. "An advance market commitment to accelerate carbon removal," Frontier Climate, https://frontierclimate.com/; "Carbon removal for our future," Counteract, accessed May 1, 2025, https://counteract.vc/; "About us," Rethinking Removals, https://rethinkingremovals.org/about-us/.

[149] "About, Coalition Members," 4 Corners Carbon Removals Coalition, accessed April 27, 2024, https://4cornerscarbon.org/.

[150] "We bring transparency and accountability to the carbon removal market," CDR.fyi, accessed May 1, 2025, https://www.cdr.fyi/; Robert Hoglund et al., *2025 CDR Market Survey: In Net Zero Standards We Trust,* Sylvera and CDR.fyi (March 5, 2025), 4, https://www.cdr.fyi/blog/2025-cdr-market-survey-report.