Large-scale anthropogenic and biogenic carbon sinks are needed to achieve Paris agreement goals

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This policy brief by the Atmosphere and Climate Competence Center (ACCC) and Climate Leadership Coalition (CLC) is based on international research publications and research conducted under the ACCC.

Key messages

- Anthropogenic and biogenic carbon dioxide removal (CDR) plays a vital role in sequestering CO2 from the atmosphere, and the deployment of CDR solutions needs to increase exponentially, similar to what has been seen with the solar and wind energy over the past decade.
- Achieving this requires a CO2 price incentive, robust and transparent carbon sink measurements and an adequate regulatory framework that includes the role of CDR in Nationally Determined Contributions (NDCs). Following the Global Stocktake, future COPs must explicitly acknowledge the magnitude of the CDR gap, update carbon budget objectives for at least 2070, and preferably 2100, and instigate new negotiations on CDR.
- Deforestation should be stopped and the capacity of 'conventional' land-based CDR, primarily via afforestation, reforestation and management of existing forests, should be doubled compared to 2020 levels in line with the 1.5 °C pathway. Novel CDR solutions, such as direct air capture and storage, bioenergy with carbon capture and storage, enhanced weathering and new carbon-rich materials should be developed and deployed at scale within this decade.

Introduction

Copernicus data (1) shows that the global average temperature – accelerated partly by the El Nino effect – for the past twelve months (June 2023–May 2024) was 1.63 °C above the 1850-1900 pre-industrial average. This kind of development was predicted in the IPCC AR6 report in 2023 (2), which noted that by 2030 the global surface temperature in any individual year could exceed 1.5 °C relative to 1850–1900 levels.

According to recent estimations by Imperial College (3), the carbon budget for +1.5 °C with 66% certainty (60 GtCO2 after 1/2023) will be closed during summer 2024 under current CO2 emissions levels (40 GtCO2/y) and with 50% certainty by 2029 (247 GtCO2 after 1/2023).

The rising global temperature and vanishing carbon budget mean that virtually all anthropogenic CO2 emissions, from now on, need to be sequestered from the atmosphere and stored permanently to enable a return to the +1.5 °C level following a now inevitable overshoot. We may need to sequester even more than this, due to the decreased cooling effect of sulphate and other anthropogenic aerosol species, the warming effect of the oceans and the weakening of biosphere and ocean carbon sinks (4).

In Finland, we have seen the warning signals of weakening biome carbon sinks: the capacity of the forest land sink shrank by 4.6% between 2021 and 2022 due to the decreased soil sink of upland

forests and increased soil-derived CO2 emissions from drained peatland forests. The increase in soil-derived emissions from peatland forests is a direct result of global warming, which is accelerating peat decomposition (5). A slowdown in forest growth has also been observed in Sweden and Norway during recent years (6).

Given the significant uncertainty surrounding the magnitude and sustainability of terrestrial carbon sinks under future climate conditions, the need for additional measures has to be urgently addressed (7).

Figure 1 illustrates how the Paris agreement goals could be achieved by the end of the century. CO2 emissions will need to be cut by half every decade to reach net-zero emissions by 2050, and from then onwards vast amounts of CO2 will have to be captured from the air for many decades, cleaning up the atmosphere and returning atmospheric CO2 to climate-safe levels.

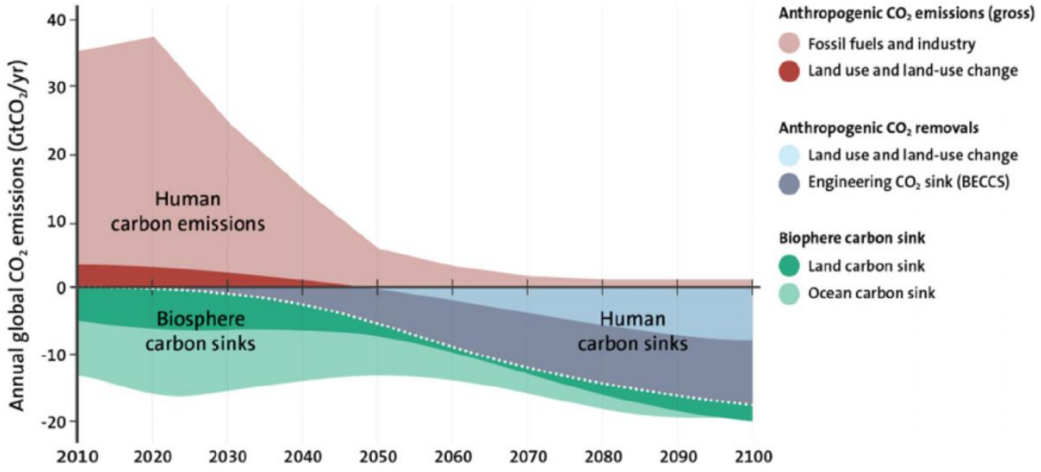

Figure 1. A scenario to achieve the Paris climate goals (adapted from Rockström et al. 2017) (8).

Anthropogenic and biogenic carbon dioxide removal (CDR) plays an important role in sequestering CO2 from the atmosphere. Deforestation should be stopped and 'conventional' land-based CDR, primarily via afforestation, reforestation and management of existing forests, should be doubled compared to 2020 levels in line with the 1.5 °C pathway (9).

Novel CDR solutions, such as direct air capture and storage, bioenergy with carbon capture and storage, enhanced weathering and new carbon-rich materials should be developed and deployed at scale within this decade. However, as there is large uncertainty in climate sensitivity and the feasibility of gigaton-scale CDR methods, strong near-term emission reductions are urgently needed with CDR in a complementary role before reaching carbon neutrality (10). After this the role of CDR is vital as illustrated in Figure 1.

According to the State of Carbon Dioxide Removal 2nd edition report (11), the gross amount of carbon dioxide (CO2) being moved from the atmosphere into durable carbon storage is currently in the order of 2.2 GtCO2 per year, which needs to be ramped up to 7 to 9 GtCO2 per year by 2050. The deployment of CDR solutions needs to increase exponentially, similar to what has been seen with solar and wind energy over the past decade (12).

Achieving this requires a CO2 price incentive, robust and transparent carbon sink measurements and an adequate regulatory framework that includes the role of CDR in Nationally Determined Contributions (NDC). Following the Global Stocktake, future COPs must explicitly acknowledge the magnitude of the CDR gap, update carbon budget objectives for at least 2070, and preferably 2100, and instigate new negotiations on CDR.

Current state of science

There were about 27,000 English-language publications on CDR between 2000 and 2022 (9). Since the early 1990s, the number of studies on CDR has grown exponentially, by about 19% per year. Of these publications, 81% address biochar, soil carbon sequestration and afforestation/reforestation.

In comparison, in the last 10 years there were over 87,000 (13) articles published on solar power and 45,559 on 'wind turbines' (14). We can observe that CDR is still in the early phase of research and far greater contributions are needed from the scientific community.

Furthermore the total climate effect of different ecosystems including volatile organic compounds (VOCs), aerosol, clouds, precipitation and albedo need to be investigated in details (source 14) to see the potential of those to that meet the 1.5 °C target (15).

Recommendations

- Deforestation should be stopped and 'conventional' land-based CDR, primarily via afforestation, reforestation and management of existing forests, doubled compared to 2020 levels, in line with the 1.5 °C pathway.
- Novel CDR solutions, such as direct air capture and storage, bioenergy with carbon capture and storage, enhanced weathering and new carbon-rich materials should be developed and deployed at scale within this decade.
- Countries (COP parties) must develop
    - clear objectives for CDR and define whether CDR will contribute to net emissions reductions, counterbalancing residual emissions or reaching net-negative emissions
    - a CO2 price incentive for carbon sinks and storages
    - robust and transparent carbon sink measurements
    - an adequate regulatory framework that addresses the role of CDR in Nationally Determined Contributions
- Future COPs must:
    - explicitly acknowledge the magnitude of the CDR gap following the Global Stocktake
    - update carbon budget objectives for at least 2070, and preferably 2100
    - instigate new negotiations on CDR
- Research and development of CDR – both natural and technical – should be included and prioritised within public R&D initiatives, likewise pursuing a deeper understanding of how climate change will affect natural carbon cycles.

Further information

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Climate Leadership Coalition (CLC) is the largest non-profit climate business network in Europe. CLC has 99 organizational members employing globally close to 1 million people and represent almost 70 % of the market cap of the OMX Nasdaq Helsinki stock exchange.