The importance of Carbon Dioxide Removal (CDR) for reaching Paris Climate Goals: Current research activities and new insights

The global warming outcome of mitigation pathways is determined by three key elements

1. 
2. 
3. 

CO₂ removal (CDR) plays several important roles
1. Reaching net zero CO₂ emissions
2. Reaching net zero greenhouse gas (GHG) emissions, which involves net negative CO₂ emissions
3. Further reducing emissions to reach net negative GHG emissions

Deeper emissions reductions until 2030 lower peak warming and reduce the reliance on CDR

- Weaker emissions reductions until 2030 result in higher transitional challenges in the next two decades and a higher reliance on CDR
- Strengthening the NDCs reduces costs as well as legal and climate risks
- 1.5°C requires a combination of all three efforts: near-term ambition, fast emission reduction 2030-2050, and a certain level of CDR.

CDR potentials are distributed unevenly across the globe raising important technical and equity issues

- Most Integrated Assessment Models (IAMs) include only a limited number of CDR options, such as BECCS and/or re- and afforestation (AR)
- Regional potentials of CDR options differ widely and can lead to imbalances and strong differences in regional strategies (see figure), e.g., Enhanced Weathering of rocks (EW) and AR
- Development of a CDR portfolio can balance regional deployment and reduce risks.

Outlook: current and future research activities

Several research projects just started:

- CDRterra (BMBF) - investigation of CDR options such as agroforestry, soil carbon sequestration, biochar, and also innovative technologies like photoelectrochemical carbon capture or long-lived materials, including an evaluation framework and sustainable CDR roadmaps for Germany and Europe.
- CDRmare (BMBF) – investigation of ocean CDR options such as ocean alkalinity enhancement, artificial upwelling, and also offshore carbon storage.
- ERC Project: GENIE (environmental, technical, social, legal, ethical and policy dimensions of CDR)
- EU horizon projects: NEGEM (Quantifying and Deploying Responsible Negative Emissions in Climate Resilient Pathways), LANDMARC (Land Use Based Mitigation for Resilient Climate Pathways), OceanNETs (ocean-based CDR technologies), ESM2025 (understanding resilience of land-based CDR approaches), PROVIDE (assessing the risk of CDR and overshoot).

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