THE STATE OF Carbon Dioxide Removal

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7–9 billion tonnes of CO_2 must be sustainably removed per year to hit climate targets

The 2024 *State of Carbon Dioxide Removal* report finds that around 7–9 billion tonnes of CO_2 per year will need to be removed by mid-century from the atmosphere if the world is to meet the 1.5°C Paris Agreement target. The authors stress that reducing emissions is the primary way to achieve net-zero, but Carbon Dioxide Removal (CDR) has a critical role to play.

This year's report is led by the University of Oxford's Smith School of Enterprise and the Environment.

The authors incorporated sustainability criteria including multiple Sustainable Development Goals into their analysis, and their final figure for a "Paris-consistent" range of CDR was assessed based on these.

Currently just 2 billion tons per year are being removed by CDR, mostly through conventional methods like tree planting. Novel CDR methods – like biochar, enhanced rock weathering, direct air carbon capture and storage (DACCS) and bioenergy with carbon capture and storage (BECCS) - contribute 1.3 million tonnes per year, less than 0.1% of the total. Methods which are effectively permanent account for only 0.6 million tonnes per year – less than 0.05% of the total.

A diverse range of CDR methods must be rapidly scaled up to address climate change in line with the Paris Agreement, say the authors. CDR has undergone rapid growth in research, public awareness and start-up companies. Yet there are now signs of a slowdown in development across multiple indicators.

While investment in CDR research and start-ups is going to an increasing variety of novel methods, few of these methods are currently targeted in government policies and proposals to scale CDR, which accounts for just 1.1% of investment in climate-tech start-ups. "Given the world is off track from the decarbonisation required to meet the Paris temperature goal, this shows the need to increase investment in CDR as well as for zero-emission solutions across the board," says Dr Steve Smith of the Smith School of Enterprise and the Environment, University of Oxford.

The report notes that CDR companies have high ambitions which, taken together, would drive CDR to levels consistent with meeting the temperature goal of the Paris Agreement.

However, the authors say these ambitions have little ground for credibility at present and depend on a much stronger set of policies than currently exists.

The report urges governments to implement policies that will increase demand for carbon removals. These should include the embedding of CDR policies into countries' Nationally Determined Contributions (climate action plans under the UNFCCC) and developing better monitoring, reporting and verification systems for CDR. At present, much of the demand for CDR is coming from voluntary commitments by companies to buy carbon removal credits.

Dr Steve Smith, Smith School of Enterprise and the Environment, comments:

"There are some encouraging signs in the growth and diversity of CDR research and innovations. But these are tempered strongly by sparse and precarious long-term demand. Governments have a decisive role to play now in creating the conditions for CDR to scale sustainably."

Dr Oliver Geden, German Institute for International and Security Affairs, comments:

"Deploying a diverse CDR portfolio is a more robust strategy than focusing on just one or two methods. Research, invention, and investment in start-ups show diversification across CDR methods. However, current deployment and government proposals for future implementation are more concentrated on conventional CDR, mainly from forestry."

Matthew J. Gidden, Senior Scholar, International Institute for Applied Systems Analysis, IIASA, comments:

"It is clear that delaying crucial emissions reductions only exacerbates needed mitigation in the future to limit warming well below 2°C, but there are limits to the role sustainable CDR can play the longer the world delays."

Dr. Stephanie Roe, Global Climate and Energy Lead Scientist, WWF, comments:

"To meet the Paris Agreement, any kind of climate mitigation must be done sustainably. This report finds that the more sustainable scenarios have higher amounts of emissions reductions and therefore deploy less CDR cumulatively. For the CDR that is needed, it is vital that environmental and social sustainability are explicitly embedded into planning and policy to minimize risks and maximize co-benefits."

The annual *State of Carbon Dioxide Removal* report is a combined effort of over 50 international experts. It is the world-leading scientific assessment of how much carbon dioxide removal will be needed to limit climate change, and whether or not the world is on track to deliver.

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The *State of Carbon Dioxide Removal* report was devised and convened by researchers Oliver Geden (German Institute for International and Security Affairs, SWP), Matthew J. Gidden (International Institute for Applied Systems Analysis, IIASA), William F. Lamb (Mercator Research Institute on Global Commons and Climate Change, MCC), Jan Minx (Mercator Research Institute on Global Commons and Climate Change, MCC), Gregory Nemet (University of Wisconsin-Madison) and Stephen M Smith (Smith School of Enterprise and the Environment, University of Oxford). Each are leading academics in the field of CDR, lead investigators within major CDR assessment projects, and IPCC authors.

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Defining CDR

CDR involves capturing CO_2 from the atmosphere and storing it durably on land, in the ocean, in geological formations or in products. Examples include reforestation, biochar, bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS). Some means of storage are longer-lasting and less vulnerable to reversal than others.

CDR vs CCS

CDR is not the same thing as Carbon Capture and Storage (CCS). To count as CDR, a method must capture CO_2 from the atmosphere. While some CDR methods such as BECCS and DACCS will use the same CO_2 transport and storage infrastructure as CCS, CCS usually refers to a set of industrial methods for the capture of CO_2 from fossil sources.

About the Smith School of Enterprise and the Environment
The Smith School of Enterprise and the Environment at the University of Oxford equips enterprise to achieve net zero emissions and the Sustainable Development Goals, through world-leading research, teaching and partnerships.
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