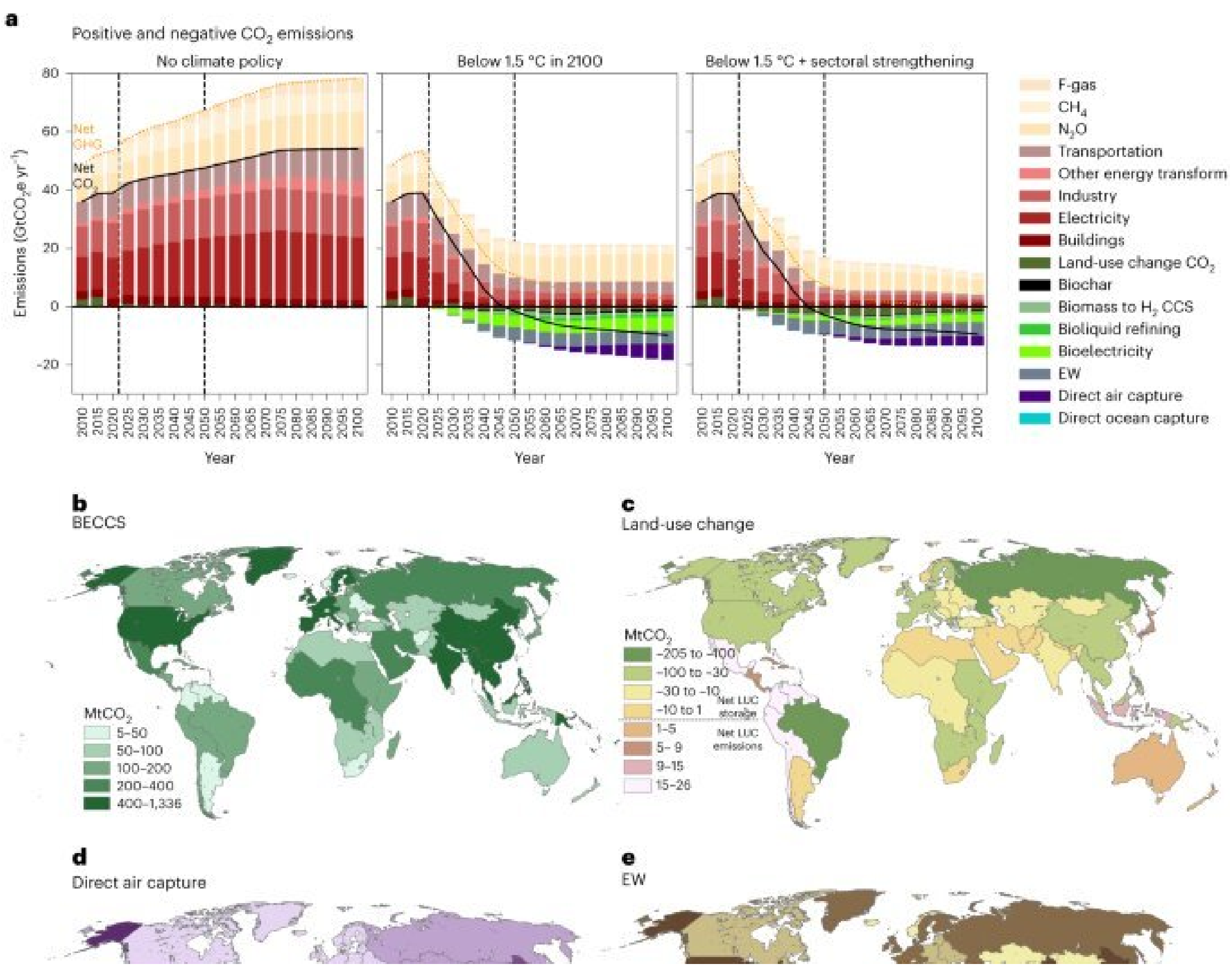
Taking a diverse approach is key to carbon removal, says new study

March 9 2023, by Brendan Bane



CO_2 emissions and removals. Credit: *Nature Climate Change* (2023). DOI: 10.1038/s41558-023-01604-9

Diversification reduces risk. That's the spirit of one key takeaway from a new study led by scientists at the Department of Energy's Pacific Northwest National Laboratory. The effective path to limiting global warming to 1.5 degrees Celsius by the end of this century likely requires a mix of technologies that can pull carbon dioxide from Earth's atmosphere and oceans.

Overreliance on any one carbon removal method may bring undue risk, the authors caution. And we'll likely need them all to remove the necessary amount of carbon dioxide—10 gigatons annually—to secure just 1.5 degrees of warming by 2100.

The new work, published today in the journal *Nature Climate Change*, outlines the carbon-removing potential of six different methods. They range from restoring deforested lands to spreading crushed rock across landscapes, a method known as enhanced weathering.

This study marks the first attempt to incorporate all carbon dioxide removal approaches recognized in U.S. legislation into a single integrated model that projects how their interactions could measure up on a global scale. It does so while demonstrating how those methods could influence factors like water use, energy demand or available crop land.

The authors explore the potential of these carbon removal methods by modeling decarbonization scenarios: hypothetical futures that demonstrate what kind of interactions could crop up if the technologies were deployed under varying conditions. They explore pathways, for example, where no climate policy is applied (and warming rises to 3.5 degrees as a result).

A second pathway demonstrates what amount of carbon would need to be removed using the technologies under an ambitious policy in which carbon emissions are constrained to decline to net-zero by mid-century and net-negative by late-century to limit end-of-century warming to below 1.5 degrees.

The third scenario follows the same emissions pathway but is paired with behavioral and technological changes, like low material consumption and rapid electrification. In this scenario, these societal changes translate to fewer overall emissions released, which helps reduce the amount of residual greenhouse gas emissions that would need to be offset with carbon removal to meet the 1.5-degree goal.

To meet that target—the original goal of the Paris Agreement—the authors find that roughly 10 gigatons of carbon dioxide must be removed per year. That amount remains the same even if countries were to strengthen efforts to reduce carbon dioxide emissions from all sources.

"Bringing us back down to 1.5 degrees by the end of the century will require a balanced approach," said lead author PNNL scientist Jay Fuhrman, whose work stems from the Joint Global Change Research Institute. "If one of these technologies fails to materialize or scale up, we don't want too many eggs in that basket. If we use a globally diverse portfolio of carbon removal strategies, we can mitigate risk while mitigating emissions."

Some of the technologies stand to contribute a great deal, with the potential to remove several gigatons of carbon dioxide per year. Others offer less, yet still stand to play an important role. Enhanced weathering, for example, could remove up to four gigatons of carbon dioxide annually by mid-century.

Under this method, finely ground rock spread over cropland converts carbon dioxide in the atmosphere into carbonate minerals on the ground. It is among the most cost-effective methods identified in the study.

In comparison, direct ocean capture with carbon storage, where carbon dioxide is stripped from seawater and stored in Earth's subsurface, would likely remove much less carbon. On its own, the nascent technology is prohibitively expensive, according to the authors. Pairing this method with desalination plants in regions where demand for desalinated water is high, however, could drive down the cost while delivering more meaningful carbon reductions.

In addition to the removal methods mentioned above, the technologies under study include biochar, direct air capture with carbon storage, and bioenergy paired with carbon capture and storage.

Each of the technologies modeled brings unique advantages, costs and consequences. Many of those factors are tied to specific regions. The authors point out Sub-Saharan Africa as an example, where biochar, enhanced weathering and bioenergy with carbon capture and storage stand to contribute significant reductions.

Yet the authors find much work is needed to address greenhouse gases other than carbon dioxide, like methane and nitrous oxide. Many of these non-CO_2 gases are several times more potent while simultaneously more difficult to target than carbon dioxide.

While some of the removal methods examined within the new paper are well-studied, their interactions with other, newer methods are less clearly understood. The work originates from the Joint Global Change Research Institute, a partnership between PNNL and the University of Maryland where researchers explore interactions between human, energy and environmental systems.

Their work focuses on projecting what tradeoffs may flow from a range of possible decarbonization scenarios. The authors seek to better understand how these methods interact so that policymakers may be informed in their efforts to decarbonize.

"This study underscores the need for continued research on carbon dioxide removal approaches and their potential impacts," said corresponding author and PNNL scientist Haewon McJeon. "While each approach has its own unique benefits and costs, a diverse portfolio of carbon dioxide removal approaches is essential for effectively addressing climate change. By better understanding the potential impacts of each approach, we can develop a more comprehensive and effective strategy for reducing greenhouse gas emissions and limiting global warming."

More information: Jay Fuhrman et al, Diverse carbon dioxide removal approaches could reduce impacts on the energy–water–land system, *Nature Climate Change* (2023). DOI: 10.1038/s41558-023-01604-9

Provided by Pacific Northwest National Laboratory