Study finds limits to storing CO_2 underground to combat climate change

August 28 2024

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Imperial College London research has found limits to how quickly we can scale up technology to store gigatonnes of carbon dioxide under Earth's surface.

Current international scenarios for limiting global warming to less than 1.5 degrees by the end of the century rely on technologies that remove carbon dioxide (CO_2) from Earth's atmosphere faster than humans release it. This means removing CO_2 at a rate of 1–30 gigatonnes per year by 2050.

However, estimates for the speed at which these technologies can be deployed have been highly speculative. Now, findings from a new study led by Imperial College London researchers show that existing projections are unlikely to be feasible at the current rate of growth.

The study found that it might be possible by 2050 to store up to 16 gigatonnes of CO_2 underground each year. However, reaching this target would require a huge increase in storage capacity and scaling over the coming decades, which is not anticipated given the current pace of investment, development and deployment.

With the UK Government aiming to position Britain as a clean energy superpower and scale up and invest in carbon capture and storage, the study underscores the importance of aligning ambitious initiatives with realistic objectives for how quickly CO_2 can be safely stored underground.

The results are published in *Nature Communications*.

Realistic goals

The team from Imperial's Department of Earth Science and Engineering created models showing how quickly carbon storage systems can be developed and deployed, accounting for the availability of suitable geology, and technical and economic limitations to growth.

While the results suggest it is possible to reduce CO_2 emissions at a huge scale, they also suggest that the path to achieving this and the contribution from key regions might differ from what current models project, including those from Intergovernmental Panel on Climate Change (IPCC) reports.

Lead author Yuting Zhang, from Imperial's Department of Earth Science and Engineering, said, "There are many factors at play in these projections, including the speed at which reservoirs can be filled as well as other geological, geographical, economic, technological, and political issues. However, more accurate models like the ones we have developed will help us understand how uncertainty in storage capacity, variations in institutional capacity across regions, and limitations to development might affect climate plans and targets set by policymakers."

Co-author Dr. Samuel Krevor, also from Imperial's Department of Earth Science and Engineering, said, "Although storing between 6 to 16 gigatonnes of CO_2 per year to tackle climate change is technically possible, these high projections are much more uncertain than lower ones. This is because there are no existing plans from governments or international agreements to support such a large-scale effort.

"However, it's important to keep in mind that 5 gigatonnes of carbon going into the ground is still a major contribution to climate change mitigation. Our models provide the tools to update current projections with realistic goals for how and where carbon storage should be developed in the next few decades."

Existing projections unlikely to be feasible

In their analysis, the researchers found that the IPCC included results from integrated assessment models (IAMs)—tools combining different sources of information to predict how carbon storage methods can impact our climate and economy—that often overestimate how much

CO_2 can be stored underground.

In particular, the analysis suggests that projections from IPCC reports for Asian countries including China, Indonesia and South Korea, where current development is low, assumed unrealistic rates of deployment—which means existing projections are unlikely and unreliable.

Co-author Professor Christopher Jackson, also from Imperial's Department of Earth Science and Engineering, said, "While integrated assessment models play an important role in helping climate policymakers make decisions, some of the assumptions they make when it comes to storing large amounts of carbon underground appear unrealistic."

Global benchmark

The team's calculations suggest that a more realistic global benchmark is in the range of 5–6 gigatonnes of storage per year by 2050. This estimate aligns with how existing, similar technologies have been scaled up over time.

Their modeling approach uses growth patterns observed in real-world data from different industries, including mining and renewable energy. By looking at how these industries have grown in the past, and combining existing amounts of stored CO_2 with a flexible framework to explore different scenarios, the new approach offers a reliable way to make attainable, long-term projections for underground CO_2 storage and could be a valuable tool for policymakers.

Dr. Krevor said, "Our study is the first to apply growth patterns from established industries to CO_2 storage. Existing predictions rely on speculative assumptions, but by using historical data and trends from other sectors within the industry, our new model offers a more realistic and practical approach for predicting how quickly carbon storage can be scaled up—helping us set more attainable targets."

More information: The feasibility of reaching gigatonne scale CO2 storage by mid-century, *Nature Communications* (2024). Pre-print: www.researchsquare.com/article/rs-4011559/v1

Provided by Imperial College London

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