Skip to content ↓

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Navigation

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- All News

- Research
- Health & Medicine
- Campus
- Academics
- Student Experience

- For Journalists
- Media Contacts
- Experts Guide

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[Research](#)

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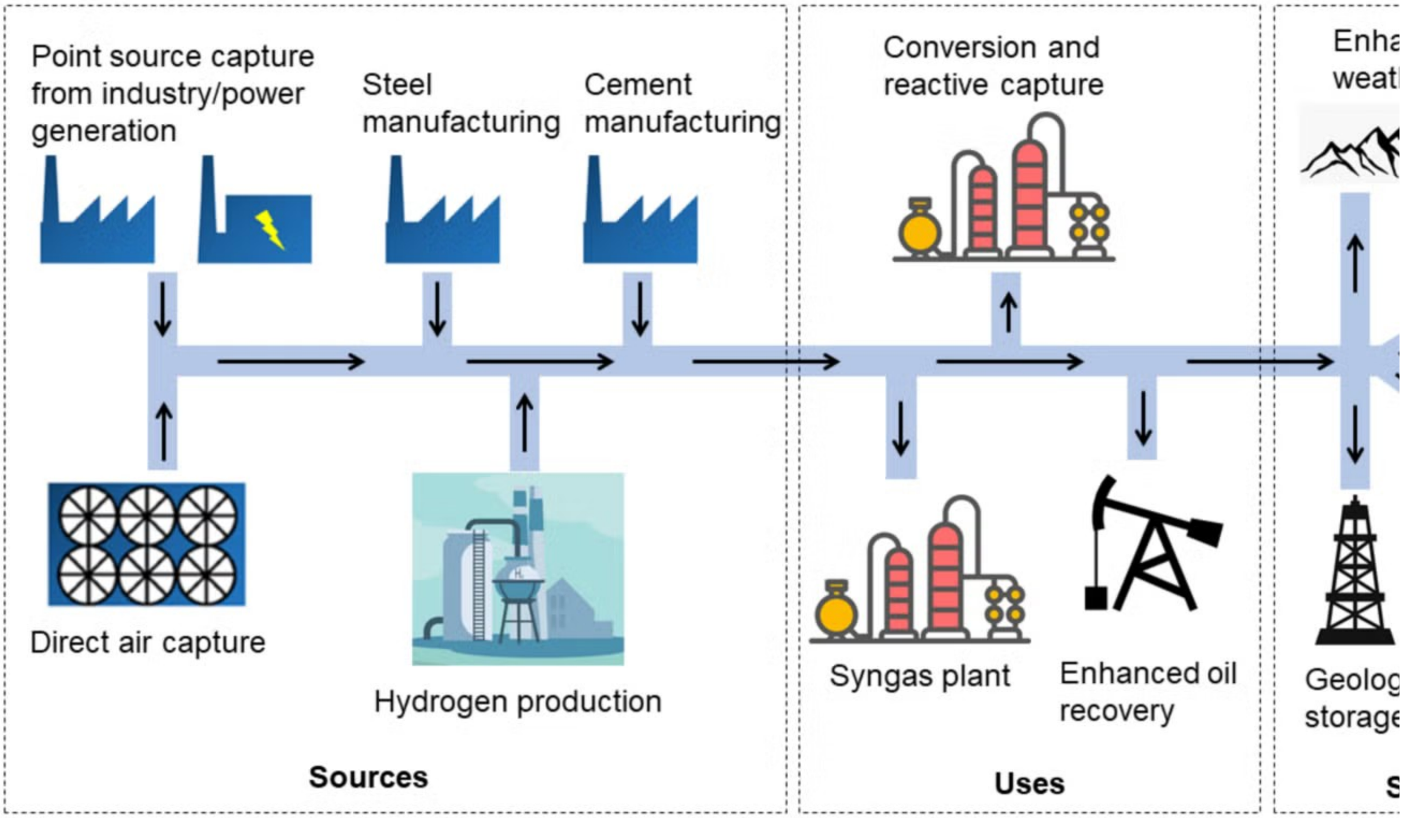
UT Researchers Map the Path to Viable Carbon Capture

Cross-disciplinary team proposes a systems approach to make carbon management economically viable

Five researchers at The University of Texas at Austin are bridging engineering and public policy to address one of climate science's most pressing challenges. The team, which spans several disciplines in the Cockrell School of Engineering and the LBJ School of Public Affairs, is creating a "research road map" to find better carbon capture processes.

"Most people who work on these carbon problems are either geologists or some flavor of engineers, so it tends to be very technology-focused," said Hugh Daigle, the team leader and professor of petroleum engineering. "On the other side, you've got the energy-system-modeling people, who are more on the economist side. There is a big chasm between those two. What we're trying to do is bring it all together in a way that hasn't happened before."

The collaboration, supported by an [Incubator planning grant](#) from UT's Office of the Vice President for Research, Scholarship and Creative Endeavors, includes Daigle, Arvind Ravikumar in petroleum and geosystems engineering; Sergio Castellano in civil, architectural and environmental engineering; Benjamin Leibowicz in mechanical engineering; and Andrew Waxman at the LBJ School.



The collaboration came about as the result of a yearly competition sponsored by UT's Office of the Vice President for Research, Scholarship and Creative Endeavors called the Bold Inquiry Incubator.

Hugh Daigle

"If we're going to make carbon removal something that works, we're going to have to think about this as a big, complicated, industrial system," Daigle said.

Carbon must be captured, transported and then used or stored. Each step involves technology choices with pros and cons. "We want to encourage this kind of system-level thinking about the entire carbon management ecosystem including technology development, reducing community harm and various legal policy and tax incentive structures," Daigle said.

Arvind Ravikumar

Economics remains the biggest barrier. “Solar, wind and storage are rapidly gaining market share right here in Texas because they have near zero operational costs,” Ravikumar said. “By contrast, adding carbon capture to natural gas power plants raises costs, making those facilities uncompetitive without substantial tax incentives.”

Companies today can capture their own emissions or purchase carbon credits, but without better economics, widespread adoption remains elusive.

The team has identified six core research areas for developing an integrated carbon management ecosystem:

Capture and Removal Technologies

Currently, capturing carbon happens at the point of the pollution or by direct air capture, both of which are extremely expensive. A promising cost-reduction approach combines these two capture systems with large-scale, nature-based “drawdowns,” including enhanced rock weathering, in which rocks such as limestone are ground into powder to increase their surface area for carbon absorption. Crops, forests and other forms of biomass also serve as carbon “sinks.”

Measurement and Accounting

Robust systems for measurement, reporting and verifying carbon capture are critical for an effective marketplace. Ravikumar has done extensive work on measurement and accounting frameworks for methane that could serve as a model.

“When you look at the carbon offset market right now, it’s the Wild West,” Daigle said. “For the market to work, you need to have something that everybody agrees on that’s transparent and correct.”

Sequestration and Utilization

Any carbon-management system requires a “sink” of CO_2 to keep emissions out of the atmosphere and must be carbon-negative overall. Some solutions appear carbon-negative in the short term but become carbon-positive in the long term, for example, if grinding rocks for enhanced rock weathering requires burning more carbon than those rocks absorb.

CO_2 capture supports downstream businesses such as synthetic fuel production, but these processes are energy-intensive, and burning the fuel releases CO_2. While companies can profit from utilization through tax credits, carbon offsets, or product sales, Daigle questions whether future demand will match capture capacity. “Where is all that carbon going to go? There’s a supply-and-demand issue there,” he said.

Technology Integration and Systems Analysis

Game theory can model the effects of subsidies and other policy decisions. The team says future work should consider the spatial scales of infrastructure, business models and industry structures, while recognizing that models must be adapted for different countries’ incentives and regulations.

The Economic and Policy Dimensions

Andrew Waxman

Waxman focuses on translating engineering into policy and economic insights about real-world performance, including actual costs, learning curves and investment uncertainty. “My goal is to help design climate policies that encourage socially optimal investments, manage tradeoffs, and ensure carbon capture delivers real climate benefits at the lowest possible cost to society.”

Applications include enhanced oil recovery, carbonated beverages, and “green cement,” which reduces emissions from an industry that produces 8% of global heat-trapping gases.

Community Impacts

Finally, the team stresses the benefits of community engagement, which includes maintaining local support; fostering a local, engaged workforce; providing feedback on operations; and ultimately reducing risk for companies pursuing carbon-management activities.

“We’re interested in assessing…how communities can be involved but also potentially benefit or be impacted by the development and management of carbon capture systems,” Castellanos said.

The Path Forward

Sergio Castellanos

Carbon capture utilization and storage (CCUS) technologies can contribute significantly to reducing greenhouse gas emissions within our lifetimes, Leibowicz says.

"CCUS provides a path for continuing to leverage the benefits of fossil fuels while mitigating their environmental impacts," he said.

Scaling up will require continued policy support and R&D. Success depends on achieving deployment levels where cost reductions drive further adoption. "The most critical role that CCUS should play in the global energy transition is to reduce [greenhouse gas] emissions from heavy industries." Leibowicz said.

Building on UT's Carbon Capture Research

Ben Leibowicz

This team's effort is only the latest of numerous advances by UT researchers in the area of capturing carbon. Others include a team that developed a technique for ultrafast formation of carbon dioxide hydrates, ice-like materials that can bury carbon dioxide in the ocean, preventing it from being released into the atmosphere.

Another team is learning to measure how much carbon can be stored in seagrass through listening to the bubbles released by the grass.

And Tip Meckel, a senior research scientist at UT's Bureau of Economic Geology, is focused on assessing the suitability of geologic formations in the Gulf of Mexico for permanent carbon storage.

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