How Does Carbon Capture Work?

The idea of removing carbon dioxide from the atmosphere to turn back the clock on climate change is an appealing one. Can these technologies deliver on their promise?

By Eden Weingart
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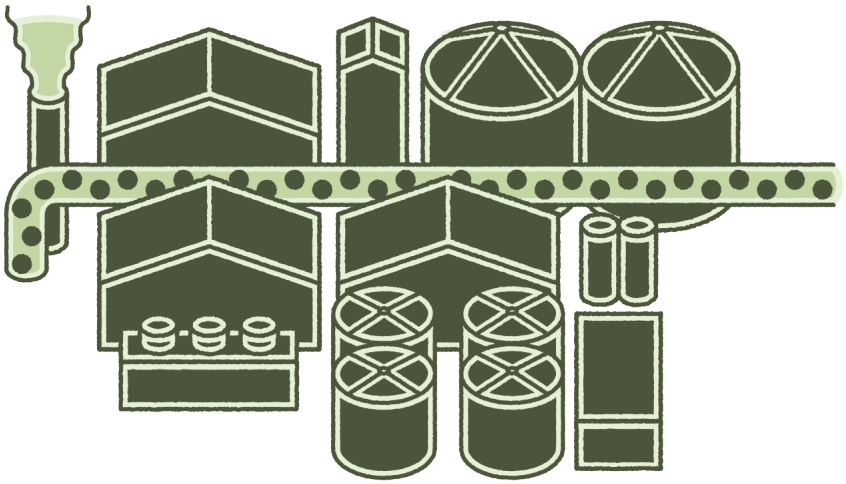
The world has a carbon problem. To solve it will require moving away from burning carbon-emitting fuels and relying instead on cleaner energy sources like wind turbines and solar cells. But is there anything we can do about all the carbon dioxide that is already in the air, and the millions of tons being emitted every day?

For most of human history, carbon emissions were balanced out by nature, said Rebecca Benner, a deputy director of the Nature Conservancy, but now we are "producing CO2 much faster than nature can recapture it."

Carbon capture is an umbrella term for technologies, some of them first proposed in the 1980s, that aim to take carbon dioxide out of the atmosphere or catch emissions and store them before they are released into the air.

Though carbon capture is not yet being done on a large scale, it is being pushed by companies and politicians as a key part of plans to guide the country to a carbon-neutral future. Encouraged by tax incentives included in the Inflation Reduction Act, some companies have proposed projects in the United States to capture CO2 and either use it or store it deep underground. Those proposals have

been met with skepticism, though, by some environmentalists who say carbon capture could distract from efforts to reduce emissions in the first place.



What is carbon capture, exactly?

Natural ecosystems like wetlands and forests absorb carbon from the air and turn it into biomass, a part of Earth's natural carbon cycle. So planting trees is a low-tech way to capture carbon, and one that we know works on a large scale. But with continued use of fossil fuels, the amount of carbon dioxide in the atmosphere is rising faster than natural processes alone have been able to counteract, and experts have sought ways to augment what nature can do.

Efforts to plant trees and other small-scale experiments are happening around the country. And two larger-scale methods are being developed: post-combustion capture and direct air capture.

Post-Combustion Capture

This technology captures emissions — called flue gas — from smokestacks at coal or natural gas power plants or factories that produce materials like concrete and steel. It is currently the main carbon-capture method being pursued in the United States, including projects in the Midwest that would trap emissions from ethanol plants. Industrial processes account for 24 percent of global carbon emissions.

Once the flue gas is captured, CO2 is separated from the gas's other components and then either put to a new use or stored.

"There are different post-combustion technologies you can use," said Howard Herzog, a research engineer at the Massachusetts Institute of Technology's Energy Initiative. The "most mature" and commercially viable method, he said, uses chemicals called amines to "scrub" the CO2 out of the flue gas. The amines bind to CO2 at lower temperatures, and then will release it again when heated, yielding close to pure carbon dioxide.

The New York Times

Direct Air Capture

To a layman, the words "carbon capture" might suggest something like a giant air filter. A technology like that does exist, and the Infrastructure Investment and Jobs Act, passed in 2021, includes money to finance a series of testing sites. But experts say that so far, direct air capture is too expensive and uses too much energy for the volume of carbon dioxide that it can capture.

Gas from an ethanol plant
Over 90% CO2

Gas from a cement plant
15% CO2

Air
0.04% CO2

The New York Times

Carbon capture is more efficient when it is used on sources with high concentrations of carbon dioxide, like the gas released during ethanol production, which is almost entirely CO2. Cement production releases a gas that is around 15 percent carbon dioxide. The atmosphere, by contrast, is about 0.04 percent carbon dioxide, so over one thousand tons of ordinary air would have to be processed in order to capture a single ton of CO2.

It's been captured. Now what?

Once captured and isolated, the CO2 is pressurized into a liquid state so that it can be transported by a pipeline to a place where it can be used or stored. Two pipeline projects currently in the works would carry carbon dioxide from Midwestern ethanol plants to sites in North Dakota and Illinois.

A Different Kind of Pipeline Project Scrambles Midwest Politics

Plans that would bury carbon underground rather than release it in the air have stoked debate over climate and property rights, creating unlikely alliances and stirring memories of fierce battles over oil.

By Mitch Smith and Alyssa Schukar
March 20, 2023

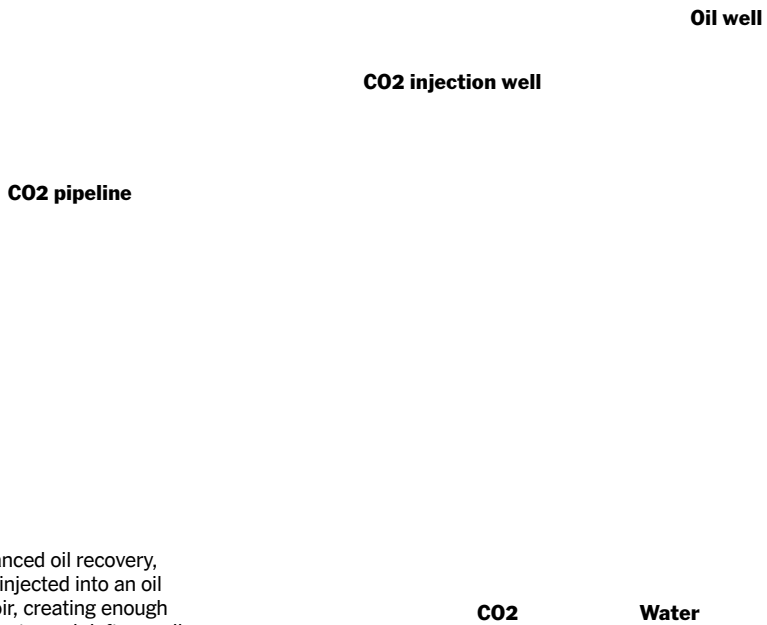
There are risks: Like any pipeline, a CO2 pipeline can rupture, as one did in Mississippi in 2020, raising concerns about safety.

“We’re not just talking about pipelines in the Midwest, but a massive nationwide build-out,” said Jim Walsh, policy director for Food & Water Watch, an environmental group that opposes the Midwestern pipeline projects. “And there is no federal oversight body for CO2 pipeline projects.”

Putting carbon dioxide to use

There are commercial uses for carbon dioxide, but many of them result in the gas eventually being released back into the atmosphere. The CO2 used to carbonate beverages, for example, begins to escape the moment a soda can is cracked open, and dry ice returns to the air as it melts.

The other primary use of CO2 is in the energy industry. The gas is injected into dwindling older oil wells to try to force more crude out of the ground. Many environmentalists are skeptical of a process that uses captured carbon to obtain more fossil fuels that will release more carbon.

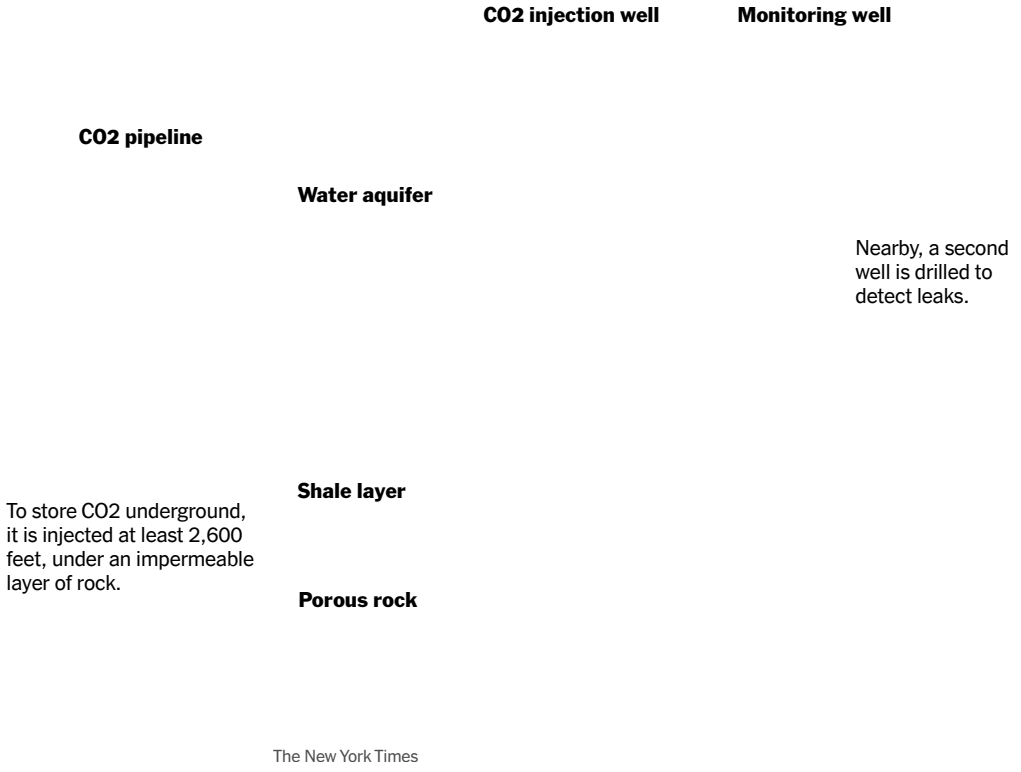


In enhanced oil recovery, CO2 is injected into an oil reservoir, creating enough pressure to push leftover oil to existing wells.

The New York Times

Sequestration

The alternative to using the carbon dioxide is storing it where it cannot escape into the atmosphere. Today, this is done by injecting it deep underground.



The New York Times

Only certain rock formations are suitable for storing carbon this way. The rock must be at least half a mile underground, deep enough to stay clear of ground water. It must be porous and permeable, like sandstone or limestone, so there will be space within it for the injected gas to occupy, the way water poured into a bucket of sand fills the spaces between the grains. And the formation must have a layer of dense rock, like shale, above it, so that the carbon dioxide won't, in theory, be able to seep out to the surface.

Can these technologies make a significant difference to climate change?

Some experts and environmentalists have pushed back against efforts to develop carbon capture, saying it is at best only a partial solution, and at worst it may impede a global transition to clean energy by letting the fossil fuel industry continue doing business as usual.

“If you’re doing too little on the emissions mitigation side, then there is no point of carbon dioxide removal,” said Glen Peters, research director at the Center for International Climate Research in Norway.

A recent study found that after taking into account the energy used to capture and isolate CO2 from flue gas at a fossil fuel-burning industrial plant, the carbon capture system would reduce the plant’s net emissions by only 10 to 11 percent, not the estimated 80 to 90 percent cited by proponents.

Others say that we need to pursue multiple routes to slow climate change “There is no 100-percent solution,” Dr. Herzog of M.I.T. said. “We need a lot of 10- and 20- percent solutions, and this is one of them.”

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