FAST COMPANY

We have the tech to suck CO2 from the air–but can it suck enough to make a difference?

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Carbon capture technology–which helps fight climate change by removing emissions that are already in the air–could be a key part of the climate solution, if it grows fast enough and doesn't just become an excuse to emit more.

[Photo: Julia Dunlop/courtesy Climeworks]

In a field on the outskirts of Huntsville, Alabama, giant fans perched on top of a shipping container pull the outside air into chambers that soak up carbon dioxide. Over a year, the equipment can capture 4,000 tons of CO_2, roughly as much as the pollution emitted by 870 cars. Run by a startup called Global Thermostat, the facility is currently the largest commercial “direct air capture” plant in the world–early proof of a technology that could help avoid the worst impacts of climate change if the captured gas is used to make carbon-neutral products or permanently stored underground. To succeed, a tiny new industry will have to radically grow.

Global Thermostat’s Commercial Plant in Huntsville, Alabama. [Photo: Global Thermostat]

The cutting-edge technology could be a pivotal piece of the larger solution for the climate crisis, and it’s at a point where it could potentially attract the investment to make that possible. Some climate researchers have criticized the tech, arguing that it’s unproven at a large scale, and that it could even constitute a moral hazard if polluting companies and countries rely on it as an excuse to avoid cutting emissions directly. A writer from the nonprofit Post Carbon Institute called it a “magic show” that distracts us from making more radical changes like limiting growth. But the UN’s climate body, the Intergovernmental Panel on Climate Change, suggests that using some type of technological means for “negative emissions” is necessary. Even if we do everything else possible to cut and capture emissions, the math doesn’t add up without it.


Global Thermostat's Commercial Plant in Huntsville, Alabama. [Photo: Global Thermostat]

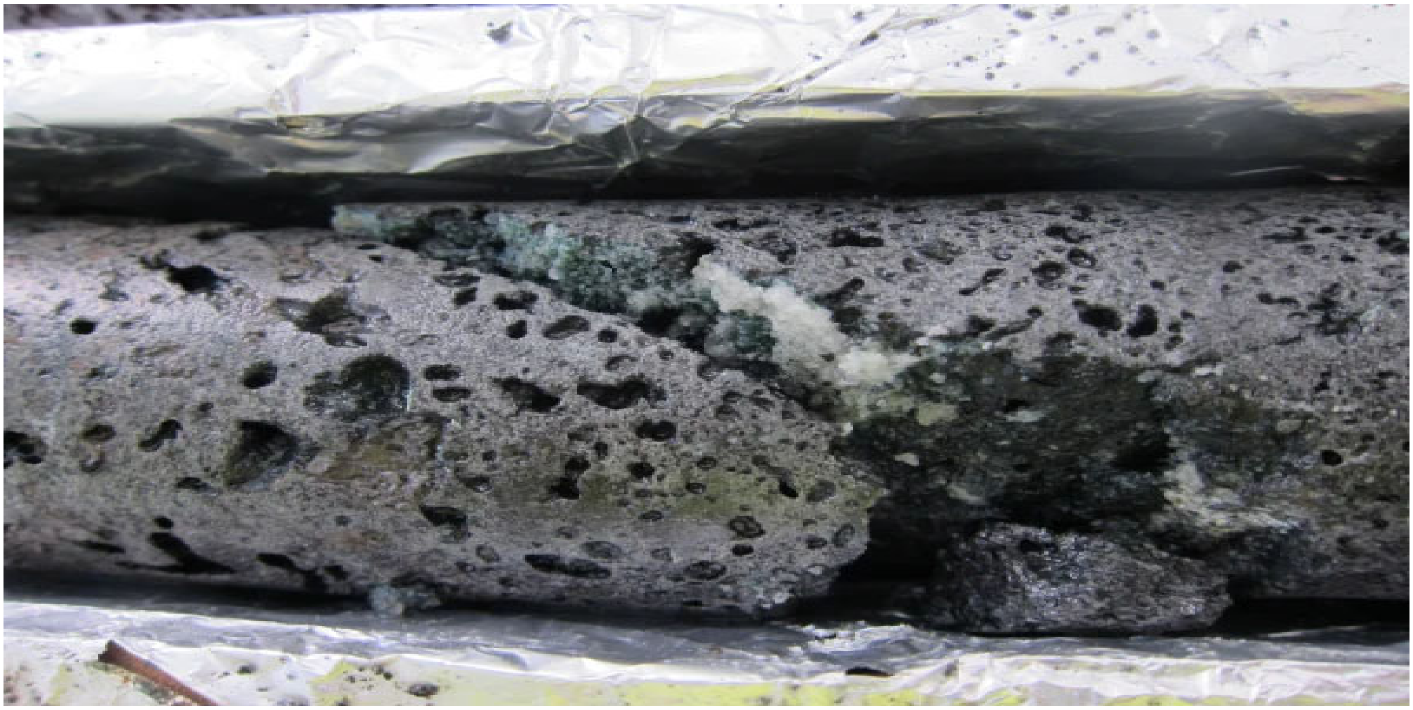
The urgency has never been clearer. This April, the concentration of carbon dioxide in the atmosphere hit 415 parts per million for the first time. It's the highest level in human history; three million years ago, when the threshold may have last risen to 400 parts per million, sea levels were 80-plus feet higher. Even if humans immediately stopped polluting the air through power plants and cars and agriculture and every other source of greenhouse gas emissions, we'd still have a problem. After stability for millennia, the average global temperature has already risen 1 degree Celsius. We're already seeing catastrophic hurricanes, droughts, and floods.

"If you look at the amount of CO2 over and above the safe level, from a climate change perspective, 95% of it is already in the air," says Steve Oldham, CEO of Carbon Engineering, a Bill Gates-backed startup that is one of a handful of companies working on direct air capture. "Each year, we emit about 5% more. Of course, we need to stop those emissions. But what about the [CO2] over the safe level that's already in the atmosphere? That's why we have to do CO2 removal."

[Photo: Carbon Engineering]

To keep the average global temperature from heating up more than 1.5 degrees– something that could save millions of lives and avoid trillions in economic costs compared to half a degree more–we need to reach net zero emissions (or carbon neutrality, meaning that for every ton of CO_2 that humans emit, it's matched by a ton that's taken out of the atmosphere) sometime between 2045 and 2055. A recent report from Rhodium Group, an independent research group, calculated that in order to reach net zero emissions in 2045, we'll need to suck between 560 and 1,850 million metric tons of CO_2 from the air with direct air capture technology every year, because a "breakneck" transition to clean energy and increasing natural solutions like planting trees isn't enough on its own.

"We found that you need everything," says John Larsen, a director at Rhodium Group who leads the firm's U.S. energy systems research. "You need to be doing as much as you can on the emission reduction side and you need to be pursuing carbon dioxide removal on all fronts." That involves replanting forests, managing farms in ways that soil can absorb as much carbon as possible, and technological approaches like injecting CO_2 underground where it can turn into rock. Direct air capture, which pulls CO_2 from the atmosphere rather than just catching pollution at a source like a power plant, and can be combined with underground storage, is another method of so-called negative emissions. It's not a replacement for trees, but it has some advantages, including the fact that it uses little land and avoids the risk of forest fires. A single Carbon Engineering plant can remove as much CO_2 as 40 million trees over the same time period.



Basalt core containing carbonates at Climework's Iceland facility.
[Photo: Sandra O Snaebjornsdottir/courtesy Climeworks]

The basic process isn't new. On submarines, scrubbers use chemicals to capture CO_2 to make the air safe to breathe. Space shuttles do the same thing. In the 1990s, a physicist named Klaus Lackner started thinking about how the idea could be applied to the problem of excess CO_2 in the atmosphere. The few startups now bringing direct air capture to market built on his ideas. The newest, Ireland-based Silicon Kingdom Holdings, is partnering with Arizona State University, where Lackner is a professor, to deploy the latest iteration of his own technology.

Climework's facility in Zurich. [Photo: Julia Dunlop/courtesy Climeworks]

Each company takes a slightly different approach. Climeworks, which opened the first small commercial plant to suck CO2 out of the air in 2016, uses modular shipping container-sized devices with fans that pull air into sponge-like filters that capture CO2 through a chemical reaction, and can then be heated to release a pure stream of the gas into pipes or tanks. Each collector captures 50 tons of CO2; six collectors fit in a shipping container, and the containers can be added together to create a larger plant. Global Thermostat, which opened its plant in Alabama in 2018, designed a variation on the process that makes it possible to release the CO2 with far less heat, saving energy. "The key advantage is that our technology is radically less expensive," says Graciela Chichilnisky, the company's CEO and cofounder. "That's very important, because it makes the technology commercial."

Climate Engineering's direct air capture pilot plant in Squamish, B.C.
[Photo: Carbon Engineering]

Carbon Engineering, which has a pilot plant on a former toxic waste site in British Columbia, uses fans to pull air into a device, where it reacts with a liquid to pull out CO2, and then flows into another vessel where another reaction creates tiny white pellets of calcium carbonate. When the pellets are heated, it creates pure CO2 that can be sold to industry for use in everything from bottling soda to making fuel, or buried underground. (If it's used in something like fuel, the product is carbon neutral rather than helping solve the problem of excess CO2.) Unlike the others, the process doesn't use filters that have to be replaced. It also uses parts that already exist in other equipment like cooling towers. "Every piece of equipment that we use is used at scale in another industry today," says Oldham. That makes it easy, he says, for the company to quickly build new plants. The company declined to share specific details about the size and design of its first commercial plants.

Lackner's technology, being commercialized by Silicon Kingdom Holdings, uses column-shaped "mechanical trees" that don't use fans, relying instead on the wind to pull air into the system. That saves energy and cost. “We’re taking a passive approach, so it doesn’t cost us anything to capture the carbon in the first instance,” says Pól Ó Móráin, CEO of Silicon Kingdom Holdings. The company, which is now beginning to design its pilot plant, estimates that the cost of capturing a ton of CO2 will be less than $100. A cluster of 12 of its “trees” captures a ton of CO2 a day. (Until recently, the cost per ton in the industry was $600; in 2018, Carbon Engineering published a paper saying that it had dropped costs to around $94 to $232 a ton. Global Thermostat thinks that it can reach $50 a ton.) CO2 can be sold for as much as $350 a ton in niche applications, like remote soda bottling plants that can’t easily access it otherwise. To be more broadly competitive, Larsen says that carbon removal costs need to be around $150 a ton.

[Photo: Julia Dunlop/courtesy Climeworks]

All of the technology works. The challenge, now, is how to scale it up. If the world had enough direct air capture to tackle current emissions of around 40 gigatons a year, it would take 40,000 of Carbon Engineering’s large plants. (The company wouldn’t disclose details about the physical size or design of its plants, but they will capture 500,000 tons of CO2 annually.) Those tens of thousands of plants shouldn’t be necessary, because emissions need to fall. But the Rhodium Group estimates that we’ll need 9 million metric tons of capacity by 2030, and perhaps as much as 136 million tons of capacity by 2040.

To do that, someone needs to pay for the CO2. It’s possible to make everything from concrete to sneakers to fish food out of captured CO2. But the cost is still higher than the alternative in most cases, and industry isn’t quite ready for it. One place to start, somewhat counterintuitively, is the oil industry: Oil companies already use CO2 for a process called “enhanced oil recovery,” pumping CO2 into the ground to boost oil production. Oil companies can get a $35-a-ton tax credit for the process, and recently added tax credits also offer $50 a ton for carbon dioxide stored underground. The companies can also choose to pump more CO2 underground than their products emit–creating carbon-neutral crude.

In March, Carbon Engineering raised $68 million in an investment round that included Chevron Technology Ventures and Oxy Low Carbon Ventures, a subsidiary of Occidental. Now, Oxy Low Carbon Ventures is partnering with Carbon Engineering on the design of a new direct air capture plant in West Texas that will be the largest in the world, pulling 500,000 tons of CO_2 from the air each year. The plant can be located next to oil wells, avoiding transportation costs.

[Photo: Carbon Engineering]

To tackle climate change, producing oil and other products, like plastic, isn't a long-term solution. Some of the startups are also starting by selling CO_2 to soda companies, where it goes into drinks that quickly release it back into the air; some are producing synthetic fuel, which does the same thing. A recent study from the Center for International Environmental Law argues that this type of technology could let oil companies keep polluting longer–making it both easier to extract oil, through enhanced oil recovery, and then giving the industry license to keep selling fuel. Carbon capture, storage, and utilization tech "further entrenches the overall fossil fuel economy," the report says.

But the biggest challenge now is to find any market that lets the fledgling industry survive, which is how the oil industry is playing a role now. "We just need money getting into the space," says Larsen. "If that money doesn't get into the space, the technology is never going to take off, and you'll never have it for all the other things we need it for." If the U.S. puts ambitious climate policy in place, the oil industry will have to transition regardless of what happens with direct air capture. And to really grow the direct air capture industry, it will need to scale up the sale of carbon credits for permanently storing CO_2 underground. (The U.S. alone, Larsen notes, has room in geological formations to store more than 400 years' worth of emissions, or more than 2 trillion tons.)

Carbon Dioxide Removal in Iceland. [Photo: Arni Saeberg/courtesy Climeworks]The direct air capture industry, he says, is at a similar place now as solar technology once was–and like solar power, it can grow with government support. The U.S. spent billions on solar R&D, and then put in place an investment tax credit in the 2000s. Now solar power is cheaper than coal. In 2018, a federal tax credit for CO2 capture and storage got bipartisan support. If that credit was expanded, and if the government provided other support through programs like procurement, it could make the difference for the industry's survival, helping plants prove themselves so more private investors come on board.

"Right now, there's not a robust market demand for people who want to buy carbon removal services," says Noah Deich, executive director of Carbon180, a nonprofit that focuses on carbon removal. "So if the government or companies can commit to procuring some fraction of the materials that they use in their buildings, for the fuels that they use for transportation, in such a way that it's using atmospheric CO2, that will be a huge signal for the companies and a way to really unlock a lot of the private sector financial interest that we're seeing."

The growth needs to happen quickly. "The challenge is not whether it can be done," says Chichilnisky. "But there is a challenge of time, because you have to do this and scale up, in a measured way, in a very short time. I'm optimistic–the technology is there. There's a trillion-dollar industry to sell CO2, and the market is there. So you can do this commercially. But the question is, can you do it as quickly as is needed now to avert the worst, catastrophic risks of climate change that are already manifesting themselves?"

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