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Pulling CO2 from air vital, but lower-cost technology a stumbling block so far: researchers

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Allen Wright, senior staff associate at the Lenfest Center for Sustainable Development, shows off a material that captures carbon dioxide from the air, which could be used to reduce atmospheric greenhouse gas concentrations. Credit: Lenfest Center for Sustainable Energy

Emerging techniques to pull carbon dioxide from the air and store it away to stabilize the climate may become increasingly important as the planet tips into a state of potentially dangerous warming, researchers from Columbia University's Earth Institute argue in a paper out this week.

The upfront costs of directly taking carbon out of the air will likely be expensive, but such technology may well become cheaper as it develops and becomes more widely used, and cost should not be a deterrent to developing such a potentially valuable tool, the authors said.

The techniques would address sources of CO_2 that other types of carbon capture and storage cannot, and have the potential to even lower the amount of CO_2 in the atmosphere -- significant because the world may already have crossed beyond the point where the climate can be stabilized by just limiting emissions.

"The field of carbon sequestration, the field of capture and storage as a community is too timid when it comes to new ideas," said lead author Klaus Lackner, director of the Lenfest Center for Sustainable Energy. "You cannot rule out new technology simply because the current implementation is too expensive."

Lackner and his colleagues at the Lenfest Center, part of the Earth Institute, summarize the technical and financial obstacles facing direct air capture of carbon in the review paper, "Urgency of development of CO_2 capture from ambient air," published July 23 in the journal Proceedings of the National Academy of Sciences. Lackner has been working on the problem for more than a decade, and he founded a company in 2004 to work toward commercializing the techniques.

Various methods are being developed to extract CO_2 directly from stationary sources such as coal-fired power facilities and steel and cement manufacturing plants, storing the CO_2 underground or using it for other purposes, such as feeding algae farms to produce biofuel. But these systems do not address the problem of emissions from mobile sources such as cars, trucks and airplanes.

CO_2 in the atmosphere, building up from humans' burning of fossil fuels and other activities, has led to warmer average temperatures across the globe, melting ice sheets and glaciers, raising sea levels and producing more frequent extreme weather events. Nine of the 10 warmest years in the modern meteorological record, since 1880, have occurred since 2000; the first six months of 2012 were the 11th warmest on record, based on land and ocean surface temperature measurements, according to the National Oceanic and Atmospheric Administration and the National Climatic Data Center.

CO_2 can linger in the atmosphere for hundreds of years; to stabilize and possibly reduce it will take concerted, long-term efforts across the globe – including the replacement of fossil fuels as an energy source. But, the authors contend, that is not likely to happen fast enough.

"Stabilizing atmospheric CO_2 will require drastic emissions reductions," the authors write. "Carbon-free renewable and nuclear energy resources are theoretically sufficient for humankind's energy needs, especially if combined with significant increases in energy efficiency. It is unclear, however, whether these resources can be deployed rapidly and widely enough and overcome socio-political obstacles related to cost, environmental impacts, and public acceptance."

That's where carbon capture and storage comes in. These emerging technologies have the potential to nearly eliminate CO_2 emissions from fossil fuel plants. But, the authors say, even modest residual emissions of 10 percent from those plants would prevent us from stabilizing atmospheric CO_2 in this century. Air capture technology could be used to mitigate that, and also to deal with the potential problem of CO_2 leaking from storage systems, some of which include pumping CO_2 deep into the ground.

And, the authors said, those systems do not address all the CO_2 coming from more diffused sources, such as in the transportation sector. Those sources account for between a third and a half of society's total CO_2 emissions.

Developing systems to capture CO_2 directly from the air could help. The paper looks at various methods. As CO_2 passes through the systems, it is pulled into absorbent liquids or surfaces, then separated out. But CO_2 is less concentrated in ambient air than it is coming out of a stationary source like a power plant. The key is to find a way to grab a lot of CO_2 out of the air with a minimum expense of energy. Estimating the cost of that technology right now is impossible, the authors said.

But if a mass-produced device could capture a ton of CO_2 per day, a million of them, like forests of artificial trees, could capture more than a tenth of humans' total output of CO_2 today.

The authors caution that the development of various types of carbon capture and storage should not be seen as an argument for doing nothing about how we burn energy.

"In a way, it's too late to argue that we shouldn't consider [such] solutions. The concern that this kind of technology would give us an excuse not to do anything [to reduce carbon emissions] is wrong, because we're too late for that," Lackner said. "We have to push very hard right now, and we have to have every means at our disposal to solve this problem."

The paper stands in contrast to a report put out last year by the American Physical Society, which flatly states that direct air capture of CO_2 "is not currently an economically viable approach to mitigating climate change."

Without dramatic cost reductions, that report contends, other options for reducing CO_2 output from decentralized sources will be more economically feasible – including increasing efficiency; switching to cars and other devices powered by electricity coming from non-carbon-based sources, such as nuclear, solar and wind; and using low-carbon fuels created from biological or other materials.

Government-sponsored efforts to foster research and development of carbon capture and sequestration are mostly focused on removing CO_2 from stationary sources, and even that technology still faces serious financial and technological challenges.

But Lackner and colleagues argue that many other technologies have started out at extremely high cost, which has dropped as the technology is refined and products are produced on mass scales. They also contend the air capture systems could reduce the cost of transporting captured carbon from stationary sources to storage sites.

"Demanding an assurance of economic viability at the outset stifles innovation, favors incrementalism and keeps game-changing ideas from consideration," the authors said. Even if the technology started with a baseline cost of $600 per ton of CO_2, the cost could probably be substantially reduced as the technology develops. "The challenge seems large but no larger than the corresponding challenges in other climate mitigation technologies," they say.

Taking CO_2 directly out of the air has been going on for decades on a small scale in submarines and spaceships. Processes for liquefying air already require removal of water and CO_2, too.

Lackner, a director and adviser to Kilimanjaro Energy, the company he founded, is studying how certain resins could absorb CO_2. He and co-author Allen Wright of the Lenfest Center are shareholders and consultants to Kilimanjaro, one of three companies working on various air capture techniques. (You can view a video of Wright explaining the technology at MIT's Technology Review.)

Another company working on air capture technology, Global Thermostat, was formed by two Columbia University professors: Peter Eisenberger, a physicist who founded the Earth Institute and formerly ran research labs for Bell Labs and Exxon, and Graciela Chichilnisky, an economist, mathematician and entrepreneur.

Lackner and Wright's co-authors include Sarah Brennan, Jürg Matter, A.-H. Alissa Park and Bob van der Zwaan, all affiliated with the Lenfest Center. Matter also works at the Earth Institute's Lamont-Doherty Earth Observatory; van der Zwaan also works for the Energy Research Centre of the Netherlands.

More information: "Urgency of development of CO2 capture from ambient air," *Proceedings of the National Academy of Sciences*

Provided by Columbia University

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