Could Air-Conditioning Fix Climate Change?

Researchers propose a carbon-neutral "synthetic oil well" on every rooftop

By Richard Conniff on April 30, 2019

Credit: Getty Images

It is one of the great dilemmas of climate change: We take such comfort from air conditioning that worldwide energy consumption for that purpose has already tripled since 1990. It is on track to grow even faster through mid-century—and assuming fossil-fuel–fired power plants provide the electricity, that could cause enough carbon dioxide emissions to warm the planet by another deadly half-degree Celsius.

A paper published Tuesday in the *Nature Communications* proposes a partial remedy: Heating, ventilation and air conditioning (or HVAC) systems move a lot of air. They can replace the entire air volume in an office building five or 10 times an hour. Machines that capture carbon dioxide from the atmosphere—a developing fix for climate change—also depend on moving large volumes of air. So why not save energy by tacking the carbon capture machine onto the air conditioner?

This futuristic proposal, from a team led by chemical engineer Roland Dittmeyer at Germany's Karlsruhe Institute of Technology, goes even further. The researchers imagine a system of modular components, powered by renewable energy, that would not just extract carbon dioxide and water from the air. It would also convert them into hydrogen, and then use a multistep chemical process to transform that hydrogen into liquid hydrocarbon fuels. The result: "Personalized, localized and distributed, synthetic oil wells" in buildings or neighborhoods, the authors write. "The envisioned model of 'crowd oil' from solar refineries, akin to 'crowd electricity' from solar panels," would enable people "to take control and collectively manage global warming and climate change, rather

than depending on the fossil power industrial behemoths."
The research group has already developed an experimental model that can complete several key steps of the process, Dittmeyer says, adding, "The plan in two or three years is to have the first experimental showcase where I can show you a bottle of hydrocarbon fuel from carbon dioxide captured in an air-conditioning unit."

Neither Dittmeyer nor co-author Geoffrey Ozin, a chemical engineer at the University of Toronto, would predict how long it might take before building owners could purchase and install such units. But Ozin claims much of the necessary technology is already commercially available. He says the carbon capture equipment could come from a Swiss "direct air capture" company called Climeworks, and the electrolyzers to convert carbon dioxide and water into hydrogen are available from Siemens, Hydrogenics or other companies. "And you use Roland's amazing microstructure catalytic reactors, which convert the hydrogen and carbon dioxide into a synthetic fuel," he adds. Those reactors are being brought to market by the German company Ineratec, a spinoff from Dittmeyer's research. Because the system would rely on advanced forms of solar energy, Ozin thinks of the result as "photosynthetic buildings."

The authors calculate that applying this system to the HVAC in one of Europe's tallest skyscrapers, the MesseTurm, or Trade Fair Tower, in Frankfurt, would extract and convert enough carbon dioxide to yield at least 2,000 metric tons (660,000 U.S. gallons) of fuel a year. The office space in the entire city of

Frankfurt could yield more than 370,000 tons (122 million gallons) annually, they say.
“This is a wonderful concept—it made my day,” says David Keith, a Harvard professor of applied physics and public policy, who was not involved in the new paper. He suggests that the best use for the resulting fuels would be to “help solve two of our biggest energy challenges”: providing a carbon-neutral fuel to fill the gaps left by intermittent renewables such as wind and solar power, and providing fuel for “the hard-to-electrify parts of transportation and industry,” such as airplanes, large trucks and steel- or cement-making. Keith is already targeting some of these markets through Carbon Engineering, a company he founded focused on direct air capture of carbon dioxide for large-scale liquid fuel production. But he says he is “deeply skeptical” about doing it on a distributed building or neighborhood basis. “Economies of scale can’t be wished away. There’s a reason we have huge wind turbines,” he says—and a reason we do not have backyard all-in-one pulp-and-paper mills for disposing of our yard wastes. He believes it is simply “faster and cheaper” to take carbon dioxide from the air and turn it into fuel “by doing it an appropriate scale.”
Other scientists who were not involved in the new paper note two other potential problems. “The idea that Roland has presented is an interesting one,” says Jennifer Wilcox, a chemical engineer at Worcester Institute of Technology, “but more vetting needs to be done in order to determine the true potential of the approach.” While it seems to make sense to take advantage of the air movement already being generated by

HVAC systems, Wilcox says, building and operating the necessary fans is not what makes direct air capture systems so expensive. "The dominant capital cost," she says, "is the solid adsorbent materials"—that is, substances to which the carbon dioxide adheres—and the main energy cost is the heat needed to recover the carbon dioxide from these materials afterward. Moreover, she contends that any available solar or other carbon-free power source would be put to better use in replacing fossil-fuel-fired power plants, to reduce the amount of carbon dioxide getting into the air in the first place.

"The idea of converting captured carbon into liquid fuel is persuasive," says Matthew J. Realff, a chemical engineer at Georgia Institute of Technology. "We have an enormous investment in our liquid fuel infrastructure, and using that has tremendous value. You wouldn't have to build a whole new infrastructure. But this concept of doing it at the household level is a little bit fantastical"—partly because the gases involved (carbon monoxide and hydrogen) are toxic and explosive. The process to convert them to a liquid fuel is well understood, Realff says, but it produces a range of products that now typically get separated out in massive refineries—requiring huge amounts of energy. "It's possible that it could be worked out at the scale that is being proposed," he adds. "But we haven't done it at this point, and it may not turn out to be the most effective way from an economic perspective." There is, however, an unexpected benefit of direct air capture of carbon dioxide, says Realff, and it could help stimulate market acceptance of the technology: One reason office buildings replace their air so frequently is simply to protect workers from elevated levels of carbon dioxide. His research suggests that capturing the carbon dioxide from the air stream may be one way to cut energy costs, by reducing the frequency of air changes.

Dittmeyer disputes the argument that thinking big is always better. He notes that small, modular plants are a trend in some areas of chemical engineering, “because they are more flexible and don’t involve such a financial risk.” He also anticipates that cost will become less of a barrier as governments face up to the urgency of achieving a climate solution, and as jurisdictions increasingly impose carbon taxes or mandate strict energy efficiency standards for buildings.

“Of course, it’s a visionary perspective,” he says, “it relies on this idea of a decentralized product empowering people, not leaving it to industry. Industrial players observe the situation, but as long as there is no profit in the short term, they won’t do anything. If we have the technology that is safe and affordable, though maybe not as cheap, we can generate some momentum” among individuals, much as happened in the early stages of the solar industry. “And then I would expect the industrial parties to act, too.”