# Carbon Capture Technologies that Could Help Fight Climate Change

**BY RICHARD SCHIFFMAN – JANUARY 29, 2013**

## Evolving technology could make cleaning the air more profitable than fouling it, says Columbia University economist

In the wake of the hottest and driest summer in memory throughout much of North America, and Superstorm Sandy that flooded cities and ravaged large swaths of the Mid-Atlantic coast, many now recognize that the climate change isn't just real, but that it is already at our doorstep.

As this realization continues to sink in, the political will may ripen to take more aggressive action to put a brake $CO_2$ emissions. Already, President Obama, who had remained mostly silent on the issue during his reelection campaign, has made it clear that tackling climate change will be among his top second-term priorities.

But the fact remains that even if the entire world switched magically to 100 percent solar and other non-polluting power sources tomorrow, it's too late to  roll back some of the impacts of climate change.  The current level of carbon dioxide in the air is already well beyond what scientists regard as the safe threshold. If we remain on our present course, scientists say, $CO_2$ levels will continue to rise — sharply— for years to come.

Climatologists tell us that the climate change train has long since left the station, but perhaps it is not yet too late to prevent it from accelerating beyond our capacity to cope. There are technologies now being developed which could cut the rate of increase of greenhouse gases, even potentially return Earth's atmosphere to preindustrial levels of $CO_2$. Better yet, the price tag for implementing them may not be all that great — especially when compared to the mounting costs of continuing down our present course. Best of all, say two scientists who are making these astonishing claims, we don't have to cut out fossil fuels entirely to accomplish it.

I met with Dr Klaus Lackner and Allen Wright at Columbia University's Earth Institute where they are working on a new "carbon capture" project which involves literally sucking carbon dioxide out of the atmosphere. The duo conduct their research in a room less than half the size of most high school chemistry labs, but teeming with vials, beakers, meters, gas canisters and other devices unnameable by a social science major like myself.

One of the tables held an array of cream-colored plastic doodads that looked  like miniature shag rugs, scrub brushes and cylindrical Christmas ornaments. A smiling Lackner handed me an object shaped like the tuft of needles at the end of a pine branch. Only instead of needles, they were thin streamers impregnated with sodium carbonate which chemically "mops up" $CO_2$ from the air.

What I was holding in the palm of my hand was a miniature prototype for an “artificial tree.” Real trees, as we learn in biology class, breathe in carbon dioxide and breathe out oxygen. The artificial tree developed by Lackner and Wright will also stand passively in the wind like a tree. But it will remove $CO_2$ from the air faster and at far higher levels than natural photosynthesis can accomplish. The team envisions creating “forests” of these carbon-capturing trees to remove carbon from the atmosphere. The $CO_2$ can then be released by a gentle flow of water, either to be used industrially or sequestered safely underground.

These units, Lackner says, will be roughly the size and production cost of a car, and collect about 1 ton a day of carbon from the air — the equivalent of the greenhouse gases produced by 36 motor vehicles in a day. Ten million of these artificial trees, he estimates, would sop up 12 percent of the $CO_2$ that humans add to the atmosphere each year.

There are already methods for scrubbing carbon dioxide emitted by stationary sources like power plant smokestacks, although this technology remains expensive and little used. Power plants account for 41 percent of manmade carbon emissions, much of the rest is produced by mobile sources — cars, trucks and airplanes. Lackner’s technology is one of the first that will have the capacity to remove vehicular carbon emissions from the air.

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His approach has little in common with controversial geo-engineering schemes to cool the earth, such as injecting vast quantities of sulfur dioxide into the stratosphere to deflect solar radiation, says Lackner. Geo-engineering, he says, “actively interferes with the dynamics of a system which you do not understand. ... It is an emergency standby which may get us through a rough decade or two, but it’s something that I’m hoping we won’t ever need to try.”

Carbon capture, by contrast, is simply cleaning up after ourselves. “We are already putting carbon dioxide into the system,” Lackner argues. “All that I am really saying is take it back.”

To environmentalists who worry that even talk of technological fixes for global warming will discourage us from the hard work of actually cutting down on greenhouse gas emissions, he responds that it is indeed crucial to shift toward clean alternative energies. But we won’t get there overnight. Lackner cited the recent International Energy Agency report which says that by 2020 the US will produce more petroleum than Saudi Arabia. In the face of this impending glut of cheap oil, he said, it is unrealistic to think that we won’t use at least some of it.

“Fossil fuels are not going to go away,” Lackner told me. “When they criticize carbon capture, it is a bit like the fiscal cliff, they are basically saying we don’t want you to have a solution and we’d rather go over the cliff. They are telling me to fight the problem with one hand tied behind my back. ... We really need all of the pieces. We will certainly need technologies to compensate for the fossil fuels that we are likely to use.”

Lackner credits his daughter, Claire, with inspiring his current line of research. As an eighth grader, Claire successfully used an aquarium pump and a solution of sodium hydroxide to take carbon dioxide out of the air, winning a first prize in the science fair.

The principle is not new. Similar technologies have been used in the enclosed spaces of submarines and space shuttles to scrub the air of excess $CO_2$. What is novel in Lackner and Wright's approach is mainly their outsized ambition, and the knotty technological problems which implementing it globally would entail. They are still trying to find a cost-effective way to further purify the $CO_2$ after it comes off the plastic leaves, and to securely bury the gas in underground or below the ocean floor.

Their biggest challenge, however, is not technical but economic: How to manufacture and market the artificial trees cheaply enough and in sufficient quantities to begin to make a real dent on global warming. In order for this to happen, there needs to be equal economic incentives for taking $CO_2$out of the atmosphere as there currently are for putting it in through the combustion of fossil fuels.

One commercial application that Kilimanjaro Energy, a San Francisco-based startup founded by the Columbia team to exploit their new technology, is already exploring selling units to greenhouse owners whose plant growth would be stimulated by high levels of $CO_2$. But even if this succeeds, the greenhouse market would be relatively small.

For carbon capture to scale up to the point where it will be meaningful, Lackner says, government will have to step in and create viable mechanisms for paying for it. He envisions a variant on the carbon-trading idea, where energy companies would be required to purchase a "certificate of sequestration" for every ton of fossil fuel they extracted. which would pay for the equivalent in $CO_2$remediation. "If you pump it out of the ground," Lackner says, "you will need to take it out of the air."

The advantage of this approach is that all green technologies like solar, wind, and carbon capture would compete on a level playing field to create carbon remediation at the lowest possible cost. The best methods would be insured a healthy profit that would fund further research and development to make them even cheaper and more efficient.

But are there ways to make carbon capture profitable that don't depend on prior government action?

Graciela Chichilnisky thinks so. The Columbia mathematical economist was the original architect of the carbon market idea, a cornerstone of the Kyoto protocol, which became international law in 2005. She was also the lead author of the Nobel Prize winning 2007 Intergovernmental Panel on Climate Change. I met her at the brownstone offices of Global Thermostat, a company that she helped set up with Peter Eisenberger, a physicist at Columbia who founded the Earth Institute.

Chichilnisky told me that carbon capture has to be made into a moneymaking proposition in its own right. This is possible, she says, because captured $CO_2$ can be sold to industries for a variety of commercial uses, including most spectacularly reconversion into relatively clean-burning carbon-based fuels, either by feeding it to oil-extruding algae, or by combining it with the hydrogen from water by electrolysis to make methanol. Chichilnisky foresees the day when oil will be manufactured in gas stations rather than transported from well-to-refinery-to-consumer as it is now.

At the moment, synthesizing fuels from $CO_2$ would be a “marginally profitable” enterprise, Chichilnisky says, but she predicts that further research and development will continue to cut costs and eventually make them fully competitive with geological extraction. Other uses like carbonating beverages, synthesizing industrial-grade formic acid, producing dry ice, and a process calledenhanced oil recovery (EOR) in which carbon dioxide is pumped into old oil wells as a solvent to scour lingering hard-to-get oil from the ground, are already up to speed.

EOR currently boosts US oil output by 10 percent a year. Chichilnisky predicts that the EOR market will rise to over $800 billion over the course of the next decade, creating a hugely enhanced demand for captured $CO_2$. The US government estimates that state-of-the-art EOR with carbon dioxide could add 89 billion barrels of oil to the nation’s recoverable oil resources. That’s more than four times the country’s proven reserves.

With demand for $CO_2$, even at present levels far outstripping supply, and companies willing to pay $100 a ton to get a hold of it, the business prospects for carbon capture look bright.

Some companies have already begun investing in this carbon capture technology.  The California-based Global Thermostat, for instance, has set up a demonstration carbon capture plant at the Stamford Research Institute in Menlo Park. The honeycomb structure that stands over 30 feet tall and captures over 2 tons of a day from power plant flue air which is pushed through it with giant fans. The system requires relatively low levels of heat to release the captured $CO_2$ from the sorbent, which it chemically bonds with. This is a great advantage, according to Chichilnisky, because it means that the units can be located in places like power plants, aluminum smelters and other industrial facilities that produce large amounts of residual process-heat.

A power plant equipped with a carbon capture unit could potentially become “carbon negative,” she says. That is to say, it could take more than twice the carbon out of the air that it puts in using only the heat that the plant itself creates. Not only would it take the $CO_2$ out of the flue gases in the plant’s smokestack, but it would remove the gas from the ambient air as well. “This reverses the paradigm that links fossil-fuel power production with carbon emissions,” Chichilnisky says. And because of the efficiency of the process that uses waste energy, the cost of $CO_2$ production could be as low as $10 to $20 a ton, she estimates. (Compare this to what the big beverage manufacturers like Coca Cola and Pepsi currently pay — about $200 a ton for the fizzy gas.)

Another place where the carbon capture units might be a boon is on oilfields that employ EOR. Producing the needed $CO_2$ *in situ* would eliminate the high cost of transporting the gas via pipeline.

Professor Chichilnisky prophecies that this evolving technology is primed to “turn the world economy on its head,” making cleaning the air more profitable than fouling it.

The challenge now has to do with figuring out how to ramp up carbon capture to levels where it would begin to put a brake on human-created climate change. “We will need to build thousands of such plants each one capturing millions of tons of $CO_2$ per year,” Chichilnisky says. “We have to accelerate the technology because this is the moment of truth, possibly the moment-of-no-return if we don’t act now.”

While she sees market forces driving much of the growth of carbon capture, Chichilnisky says that it must be “enhanced, facilitated, speeded up by the carbon market” in which industries are required to pay for their carbon emissions by funding equivalent efforts dedicated to remediation. The carrot of profits from innovative carbon capture technologies together with the stick of penalties for fouling the air will convince companies that they need to clean up their act.

How long will this take? Ten to 20 years minimum, says Chichilnisky. “Our solution is not going to be here tomorrow morning,” she says. “But we expect to succeed beautifully because the carbon market is spreading, and even before you apply the carbon market, our technology is profitable, and it works. ... And all of the carbon capture technology that we are talking about is in the US. It is almost a contradiction, the US politically is resistant to change, my God, there are people who don’t even believe in evolution. But the big scientists are here, and the most advanced innovation is here. We are in the right place at the right time and we just have to make it happen.”