MIT smokestack scrubber promises lower costs

Researchers say they can help power plants do more to cut carbon dioxide emissions

Stu Rosner

T. Alan Hatton is leading an MIT research project that got $80,000 in funding to make a small-scale commercial prototype of a carbon capture device.

By Martin LaMonica Globe Correspondent February 02, 2015

Ask people how to deal with climate change, and they often will talk about alternative energy options like solar, wind, and nuclear power.

Removing carbon dioxide, a harmful greenhouse gas, from smokestacks doesn't come up much. The technology, known as carbon capture and storage, could be a compelling alternative because of the sheer number and size of power plants that burn fossil fuels. But the high cost of removing the carbon dioxide those plants create makes the process a hard sell.

That prompted researchers at the Massachusetts Institute of Technology to try to develop a lower-cost way to do the job. Last year, they got about $80,000 in funding to make a small-scale commercial prototype.

The MIT project seeks to lower the energy needed to remove carbon dioxide by using an electrochemical device that's similar in concept to a rechargeable battery. The technique promises to be less expensive and easier to add to existing power plants than current systems.

The new system could cut energy requirements by as much as 25 percent, according to very rough estimates made in the lab. But researchers need to get closer to building a commercial system to get a firm idea of the capital costs.

MIT researchers have developed a process to capture carbon dioxide (C02) from power plant exhaust that may resolve many issues that prevent widespread adoption of today's scrubber technologies.

"It's certainly addressing an area where we haven't seen a lot of promising new technologies," said Tibor Toth, managing director of investments at the Massachusetts Clean Energy Center, which helped fund the work. "This project will allow them to really explore commercial applications and be that catalyst to attract future funding."

Given the rate of ongoing pollution — and the tons of carbon dioxide already in the atmosphere — the country needs more innovation related to carbon capture and storage, said MIT professor T. Alan Hatton and PhD candidate Aly Eltayeb, who are leading the research project.

"Carbon capture and storage is one of those things that doesn't sound sexy, but it really solves the problem," Eltayeb said. "Especially if you can do something with that CO2 and stop treating it as a waste — and treat it as a valuable product."

A single 500-megawatt coal-fired power station puts out roughly 10,000 tons of carbon dioxide each day, Hatton said. Massachusetts alone has about 20 times that capacity in fossil fuel power generation. Replacing hundreds of billions of dollars' worth of fossil fuel infrastructure with renewable energy systems would be costly and take many years.

Last year, a large carbon capture and storage project went online at a coal plant in Canada, and another is planned to start this year in Mississippi. But overall, the pace of development for such technology has been slow, with little activity on a commercial scale, the International Energy Agency says.

The problem is that the traditional process diverts roughly 30 percent of a plant’s power output to remove carbon dioxide, Hatton said. All of that energy costs money, which is ultimately paid by consumers and businesses.

Today, carbon capture is achieved with a combination of chemistry and brute force. Flue gases flow into a tank filled with a liquid that contains material called amines. The carbon dioxide latches onto the amine compounds, separating most of the carbon dioxide from the flue gas. That creates a liquid mixture of amine and carbon dioxide.

That solution is then blasted with steam. The heat forces carbon dioxide molecules to break off from the amines. Once separated, carbon dioxide is compressed and pumped into underground formations like aquifers or transported via pipelines. The amines are recycled to capture more gas.

The MIT researchers want to continue using amines but create a more energy-efficient and elegant way to split off the carbon dioxide. Four years ago, a former student in Hatton’s lab, Michael Stern, proposed using metals in an electrical device instead of steam. The idea: introduce a substance that amines would rather bind to than carbon dioxide.

He settled on a common metal, copper, because of the cost and the speed at which reactions take place.

An early prototype of an electrochemical cell consists of two metal plates, each about a foot long and a few inches wide, separated by a paper-like membrane. In a working device, a flow of electricity would create a voltage across the two plates, much the way a battery has positive and negative electrodes.

As in a traditional system, amines capture carbon dioxide from incoming flue gases. Then, the solution would flow between the two plates, which have grooves of exposed copper. Because of their chemical properties, amines and charged copper atoms have a strong attraction to each other and form a tight bond. That causes the amines to release the carbon dioxide, which is captured in a separate vessel.

The electrochemical method still requires energy — a flow of electricity — but significantly less than the steam-based carbon capture method, Hatton and Eltayeb said. They think they can improve the device and chemistry to further increase its efficiency. A commercial carbon capture machine would require hundreds or thousands of individual cells stacked together to handle a steady flow of flue gases.

Using a simple chemical process means that carbon capture gear can be bolted onto existing facilities relatively easily. It could even be installed in settings that don’t use steam, such as concrete factories, commercial buildings, spacecraft, and submarines.

“There are so many benefits when you do this electrically,” Hatton said.

If their experiments go well, Hatton and Eltayeb might choose to start a company to commercialize the technology, they said, although that would take a few years. To demonstrate the process is commercially viable, they will need to run tests with actual flue gases from power plants, rather than gases in a lab, said Richard Noble, a professor at the University of Colorado.

“This work certainly has the potential to be an alternative to conventional amine scrubber technology,” he said.

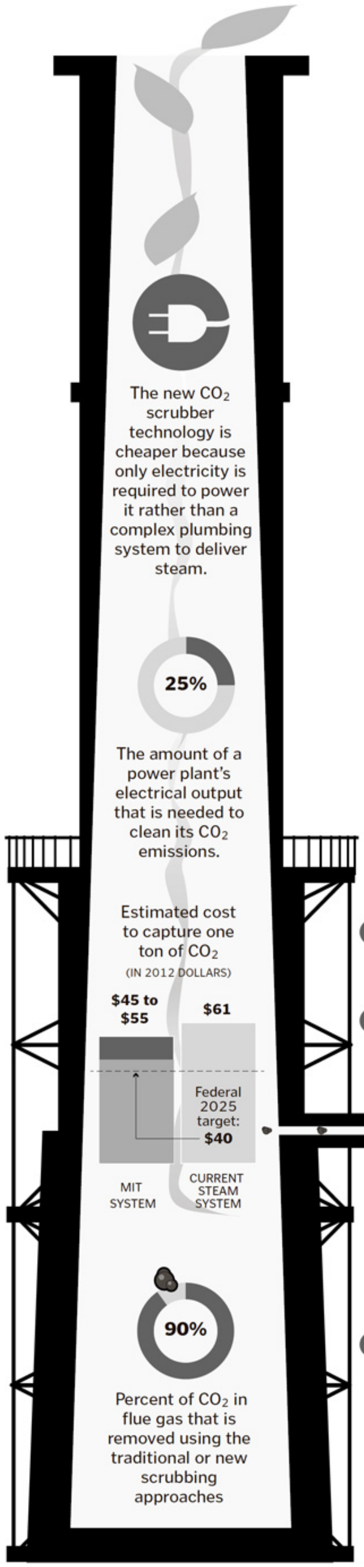
In the long term, the technology could be installed at huge power plants to separate carbon dioxide and simply sequester it underground. But initially, Hatton and Eltayeb expect the carbon dioxide will be pumped into oil and gas wells. Drillers often pump compressed carbon dioxide into wells to push out more oil.

It might seem strange to use a carbon-mitigation technology to produce more fossil fuels, but oil and gas drillers are willing to pay for pure carbon dioxide that is normally considered a waste product.

In the absence of "strong carbon policy," creating an economic incentive for carbon dioxide is critical to getting carbon capture and storage deployed, said Howard Herzog, senior research engineer at the MIT Energy Initiative. In fact, all carbon capture projects in the works plan to sell carbon dioxide for enhanced oil recovery, he said.

"Carbon capture has one primary purpose — to reduce CO2 emissions," he said. "So without policy to create markets for this, it is amazing that progress has been as good as it's been to date."

Martin LaMonica can be reached at lamonicamartin@gmail.com.



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