Rival teams hail shortcut for removing carbon from the atmosphere

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Canadian researchers working in two separate teams say they have developed a chemical shortcut that could eventually boost schemes to draw carbon out of the atmosphere and help slow the pace of climate change.

The shortcut applies to the process known as direct air capture, which aims to harvest and concentrate atmospheric carbon dioxide so that it can be used to generate renewable fuels, plastics or other products that would otherwise be derived from crude oil. While direct air capture has been shown to work at industrial scale, the new experiments featuring the shortcut have only been demonstrated in the laboratory. But if they can be scaled to commercial size they could significantly improve the efficiency and economics of the direct-air-capture process.

“The really cool point of this is that it combines existing technologies in a way that bypasses some energy-intensive steps,” said Yuguang Li, a post-doctoral researcher at the University of Toronto who co-led one of the efforts, which published its finding Wednesday in the journal American Chemical Society Letters. Results from a second team, based at the University of British

Columbia, have been accepted for publication in the journal Joule next month.

The new developments coincide with a growing enthusiasm for direct air capture as a viable route to reducing greenhouse gas emissions, in part because of the success of a small pilot plant in Squamish, B.C., operated by the Canadian company, Carbon Engineering Ltd.

“Direct-air-capture technology has captured the attention of the public, scientists and engineers, and policy makers in the last year,” said Christopher Jones, a professor of chemical engineering at the Georgia Institute of Technology who is not affiliated with either of the Canadian teams. “While not a silver bullet … if applied on a massive scale, it could offer the potential for significant removal of carbon dioxide from the air that was emitted in the past.”

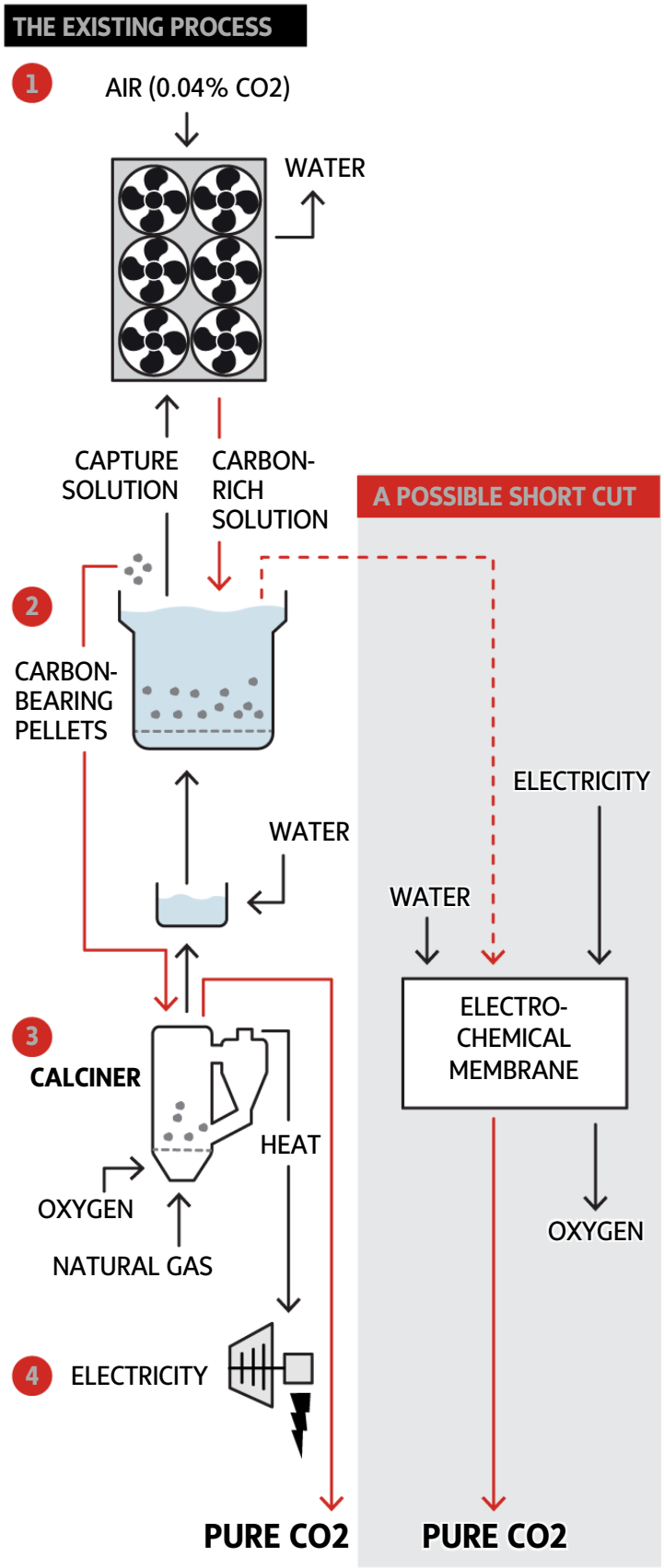
The Carbon Engineering plant works by exposing air, which contains about 0.04 per cent carbon dioxide, to a chemical solution that absorbs carbon dioxide. In a second step, carbon becomes chemically locked into solid pellets that precipitate out of the solution. The pellets are then cooked at high temperature to release carbon dioxide gas in a pure form that is suitable for storage or industrial use.

The shortcut developed by the two Canadian teams would come into play after the first step. It involves the use of an electrified material known as a bipolar membrane to generate carbon dioxide directly from the liquid solution without having to form and cook the solid pellets. The strategy comes as something of a surprise because earlier studies of related chemical reactions had suggested that such an approach would be unsuccessful.

A BETTER WAY TO CAPTURE CARBON?

In direct air capture, carbon dioxide is pulled out of the air and bound into solid pellets. The pellets are then cooked at high temperature to produce pure carbon dioxide for renewable fuel production. A possible short cut

involves using an electrified membrane to bypass the pellet stage.



STEPS TO THE EXISTING PROCESS

1

As air passes through the "contactor," the carbon dioxide it carries is exposed to a solution containing potassium hydroxide. A chemical reaction draws some of the carbon out of the air to form potassium carbonate.

2

The solution, now rich in potassium carbonate is fed into a "pellet reactor" where it is exposed to calcium hydroxide and forms solid pellets of calcium carbonate. (This process also restores the potassium hydroxide which is then sent back to the contactor.)

3

The carbon that was taken from the air is now locked in calcium carbonate. To unlock it, the pellets are heated to 900C in a device called a "calciner," which releases carbon dioxide. (The calcium-rich byproduct of this process is then mixed with water to re-form the calcium hydroxide needed for the pellet reactor.)

4

The carbon dioxide, now in pure form, can be stored or converted into a synthetic fuel in order to displace gasoline derived from crude oil.

Energy input
The calciner is heated by burning natural gas. The carbon dioxide release by the burning is also captured while the heat is used to generate the electricity needed to power the rest of the process.

THE GLOBE AND MAIL, SOURCE: CARBON ENGINEERING

"What our studies have shown is that the reaction chemistry works even though we didn't expect it to," said Curtis Berlinguette, who led the UBC team.

What both groups did not initially anticipate was the way the bipolar membrane, which has electrically positive and negative sides, acts to split water molecules and free up hydrogen ions. The hydrogen can pass through the membrane and react with the solution to produce carbon dioxide.

The Toronto team also included an additional step that turns the carbon dioxide into a combustible gas mixture known as syngas.

“Also, as a proof of principle, we show the generation of carbon products that have higher market value – ethylene as one example,” said Edward Sargent, a professor of engineering who leads the Toronto team.

Dr. Berlinguette added that his team at UBC has patented its version of the bipolar membrane approach.

David Keith, a Harvard University researcher and founder of Carbon Engineering, said the use of electrified membranes to assist in carbon capture is most likely to make an impact in small-scale systems where the approach is more competitive.

“In the long run, membrane electrochemical methods will probably win for big systems but this is not an immediate prospect,” he said.

Last week, the company announced it is moving ahead with plans for its first commercial-scale facility in partnership with a subsidiary of Occidental Petroleum Corp. The plant, which will aim to capture 500 kilotons of carbon dioxide annually, will be located at a site in Texas that is well suited to carbon sequestration.

“That site is expandable to a much larger size,” said Andrew Oldham, the company’s chief executive officer. “The challenge we face is that the first plant is always the hardest to do.”

On Wednesday, the company was also named a finalist in a Canadian government-sponsored $5-million challenge to develop sustainable jet fuel for aircraft.

Dr. Keith said that while the long-term impact of direct air capture could be to achieve a lowering of the overall concentration of carbon dioxide in the atmosphere, in the near term the focus of the technology is to reduce emissions by offering an alternative to fossil fuels for transportation.

“That’s Job 1,” he said.