

## International Patent Application Reveals Clues About C12 Energy's Carbon Capture Methodology by Eric Lane\*

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[C12 Energy](#) (C12) is a Cambridge, Massachusetts startup that recently secured a \$4.5 million round of funding led by Sequoia Capital. C12 has not made its plans public, but an article by the company's president and chief scientist published in the journal Environmental Science & Technology has been [fueling speculation](#) about a grand plan for carbon capture and sequestration.

Kurt Zenz House's [article](#), entitled "Electrochemical Acceleration of Chemical Weathering as an Energetically Feasible Approach to Mitigating Anthropogenic Climate Change," describes a process of capturing carbon dioxide from the atmosphere by enhancing the solubility of carbon dioxide in the ocean.

House's approach involves boosting the alkalinity of the ocean by electrochemically removing its hydrochloric acid and neutralizing the acid through reactions with silicate minerals. The increase in alkalinity enhances the ocean's ability to take up atmospheric CO<sub>2</sub>.

Carbon dioxide will then dissolve into the ocean and be stored as bicarbonate ion "without further acidifying the ocean." According to the article, over time the carbon will be permanently stored in the ocean:

On timescales of hundreds of years or longer, some of the additional alkalinity will likely lead to precipitation or enhanced preservation of CaCO<sub>3</sub>, resulting in the permanent storage of the associated carbon, and the return of an equal amount of carbon to the atmosphere.

The article explains that the method is "equivalent to the electrochemical acceleration of the Earth's natural chemical weathering process."

When asked about patent filings, Dr. House, who holds a Ph.D. in GeoScience from Harvard University, said that C12 is in stealth mode and he couldn't comment on the company's IP strategy.

However, Dr. House's CV, which was at one time available through his homepage, and the CV has a "Patents Filed" heading, under which it lists "Carbon Dioxide Capture and Related Processes" and states:

Primary inventor of a novel chemical process that removes CO<sub>2</sub> from the atmosphere and stores it permanently-International patent filed by Harvard University

I was able to locate House's patent application. International Application No. PCT/US2007/010032 ('032 application) was filed April 26, 2007 with the World

Intellectual Property Organization (WIPO) and published on February 14, 2008 as [WO 2008/018928](#).

The '032 application lists the owners as Harvard (where Dr. House got his Ph.D.) and the Penn State Research Foundation and claims priority to two U.S. provisional applications (provisional applications are essentially one-year placeholders which are not examined or published by the U.S. Patent & Trademark Office).

The '032 application describes and claims the carbon capture methods discussed in House's journal article. Claim 1 broadly recites the invention:

1. A process for capturing carbon dioxide comprising:
  - providing water;
  - processing the water to generate acidic solution and alkaline solution;
  - neutralizing the acidic solution; and
  - capturing the carbon dioxide from a source of carbon dioxide with the alkaline solution.

One intriguing aspect of the '032 application is the synergy with fuel cell technology it claims. Claim 33 recites an extension of the basic process wherein iron ions produced by neutralizing the acidic solution with reactive species provided from a rock and/or mineral source are oxidized in a fuel cell reaction to produce electricity.

Claim 15 recites another variation whereby the water processing step (to generate acidic solution and alkaline solution) of claim 1 is performed by electrolysis, and the electrolysis produces a halogen gas, a hydrogen gas, and sodium hydroxide. The resulting halogen gas and hydrogen gas are then reacted in a fuel cell to form the acidic solution and produce electricity.

Another method, recited in claim 36, captures CO<sub>2</sub> by reacting it with sodium hydroxide and generates chlorine gas and hydrogen gas. The hydrogen gas may be oxidized with oxygen either in a hydrogen gas turbine (claim 43) or in a fuel cell (claim 44), in each case forming water and electricity.

The written description of the '032 application states:

Another benefit of the process is that some of the steps (e.g., the formation of HCl in a fuel cell) produce useful energy that can be used in other aspects of the process. The energy may be generated, for example, from hydrogen production during the dissolution of reduced minerals (e.g., minerals comprising iron), electricity production through a fuel cell (e.g., FeCl<sub>2</sub>-HCl-O<sub>2</sub>; FeCl<sub>2</sub>-O<sub>2</sub>), or heat generated during the dissolution of silicate rocks and minerals. Because the energy cost is a large component of the total cost for most conventional CO<sub>2</sub> capture and storage technologies, the low energy cost of the process represents a valuable technological advancement.

Dr. House's article together with publication of the '032 application provides some interesting clues about C12's technology and business model. Whatever the company is planning, it wants to do it just about everywhere: the '032 application designates

countries and regions for patent protection all over the world, including the U.S., Canada, Europe, Eurasia, Africa, China, Japan, Australia and many others.

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