Title: Alternate methods of atmospheric CO2 capture

Gap/Problem statement:

Atmospheric CO2 is the ultimate source of carbon for alternative fuels. Biological systems capture CO2 and concentrate the carbon as part of their evolutionary derived processes. Alternate, non-biological methods can be imagined that extract and concentrate the CO2 so that the processing of the CO2 to a fuel can be conducted by a variety of methods. Non-biological methods to extract and concentrate CO2 can also be used to improve the efficiency of biological systems.

A key challenge is that CO2 is very dispersed, with the current concentration is on the order of 400 ppm (0.04%). Traditional methods of capture and concentration of CO2, such as absorption with solvents, membrane separation, and cryogenic methods, are energy intensive, have difficulty with the low concentrations present in the atmosphere, and often are sources for environmental contamination.

An additional challenge, is how to provide the hydrogen needed to combine with the CO2 in a thermodynamically and cost efficient manner. Hydrogen is abundant in water, but also fully oxidized, thus requiring more energy to process back into molecular hydrogen then is released by its utilization.

The challenge is to develop methods of CO2 capture and concentration and conversion to hydrocarbons that do not increase lifecycle greenhouse gas emissions, nor exacerbate environmental impacts.

Background:

Biological systems capture CO2 “naturally” with beneficial ecosystem and carbon footprint impact. Solar energy drives the process; biological systems grow to cover available land space, and acquire and use available resources, and require minimal maintenance. However, biological systems are limited in the efficiency of capture, and can be restricted by environmental considerations such as the availability of water, and require cultivation and harvest.

On the other hand, current non-biological methods are energy intensive. For example, absorption processes require pumps to move the solvents and blowers to move the gases. Similarly, membranes require the pressurization of the gases. Cryogenic systems involve significant energy to cool the gases.

Current non-biological systems are also challenged by the low concentrations of CO2 available in the atmosphere. Solvent systems are limited by equilibrium as to the concentrations that can be successfully removed. Membrane systems are driven by relative partial pressures. Cryogenic systems are very effective, but are energy intensive.

Approaches have been proposed that hybridize these approaches with methods to minimize carbon footprint. For example, natural solar driven convection has been proposed as a method to move the flows in absorption processes. Solar energy has been proposed to drive processes that require heating. Thermal gradients present in oceans could provide the necessary driving force. Innovative enzymes have been considered that are more effective at removing CO2.

An overall system solution requires that the collection of the CO2 be integrated with the manufacture of the hydrocarbons. The location of these plants in relation to the CO2 capture, the obtaining of energy and the application of hydrogen in the conversion are all keys that must be addressed.

Current Status:

As suggested in the background section, there are many potential approaches and physical processes that could be applied to collection, concentration, and conversion of CO2. The questions resolve to the economics, environmental impact, and carbon foot print of the processes. Key issues include how to address the energy requirements and sources of materials. The CO2 collection and concentration also needs to be linked to an overall system solution that can effectively employ the captured carbon dioxide and/or methods by which the carbon dioxide can be stored and transported, with little or no environmental and carbon footprint impact.

Solvability and Approaches

There are no current reasons to assume that the challenges facing these technologies cannot be resolved. Here are examples of potential approaches:

Thermally driven convection: Temperature differences, such as those present in the earth, in the sea, or in a man-made construct can be used to create convection currents that can be used to drive various scrubbing processes. The scrubbing processes would have to be optimized for the available flow rates and temperatures inherent in these systems. These systems would be necessarily large in order to create the convection required. Therefore suitable locations would need to be identified and made accessible. Such locations may have harsh environments that would have to be countered in the design and selection of materials. Such systems would then need to be linked to either the transport or utilization. It can be conceived that a facility can be built in a desert area that utilizes solar energy to drive the convective processes, with either an air or ground heat sink, coupled with some type of CO2 conversion process.

Chemical Absorption/Desorption: Ambient CO2 in the air can be removed from natural airflow passing over absorber surfaces. A selective desorption follows that release the CO2 in an enclosure. The gas is then compressed and can be used readily. [1]

Artificial trees: These proposed solutions imitate the processes that drive trees, but capture the CO2 rather than convert it to sugars. The large scale manufacture of these trees is challenging.

Solar oven: Solids capturing processes that such as those employing calcium carbonate/ calcium oxide, can be heated in a solar oven to capture CO2.

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[1] http://www.marcgunther.com/2012/03/11/direct-air-capture-of-co2-is-becoming-a-business-for-better-or-worse/

Benefits to industry as a whole

Capturing CO2 can help drive the economies of the entire system. It has the potential to capture more CO2 on a per unit area basis than biological systems. It can take place in locations that would not support biological approaches, such as deserts and oceans. The concentrated CO2 can be used as a feedstock for a variety of processes, both biological and non-biological, as well as being a chemical feedstock as well. It does not directly compete with the production of food. It does not have the potential to “infect” the environment.