PROJECT facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Sequestration

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Enhanced Practical Photosynthetic CO_2 Mitigation

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Background

Biological carbon sequestration, in particular engineered photosynthesis systems, offers advantages as a viable near-to-intermediate term solution for reduced carbon emissions in the energy sector. Photosynthetic (or “natural” sequestration) systems produce usable by-products (biomass). Further, such systems could minimize capital and operating costs, complexity, and energy required to transport CO_2 that challenge sequestration in deep aquifers or mines. Lower capital costs are extremely important, especially to small generators, who may not be able to afford separation and CO_2 delivery systems that are only cost effective if done on very large scales. For coal to remain competitive, especially in the rapidly emerging distributed generation market (< 50 MW), and to ensure future fuel diversification, a portfolio of viable and practical sequestration techniques will have to be developed. Photosynthetic systems should be a part of that portfolio. The concept behind engineered photosynthesis systems is straightforward. Even though CO_2 is a fairly stable molecule, it is the basis for the formation of complex sugars by green plants through photosynthesis. The relatively high content of CO_2 in flue gas (approximately 14% compared to 350 ppm in ambient air) has been shown to significantly increase growth rates of certain species of microalgae. Therefore, application is ideal for contained systems, engineered to use specially selected strains of microalgae to maximize CO_2 conversion to biomass, absorbing greenhouse gases. In this case, the microalgal biomass represents a natural sink for carbon.

Primary Project Goal

The main purpose of this research is to demonstrate and optimize low-risk methods of CO_2 mitigation based on existing biological organisms capable of significant CO_2 uptake and offer a valid near-term solution for the CO_2 sequestration problem.

Objectives

The project will demonstrate the technical and economic feasibility of using an ‘optimized’ enhanced photosynthesis system that (a) separates and uses various spectral regions of direct, non-diffuse sunlight to maximize cyanobacteria growth, (b) directly decreases CO_2 concentrations in the emissions of fossil generation units, (c) reduce the required space needed (compared to other biological techniques) by an approximate factor of 25, and (d) simultaneously produce enough electrical energy to nearly self-power the entire sequestration system.

ENHANCED PRACTICAL PHOTOSYNTHETIC CO_2 MITIGATION

PROJECT PARTNERS

Ohio University

COST

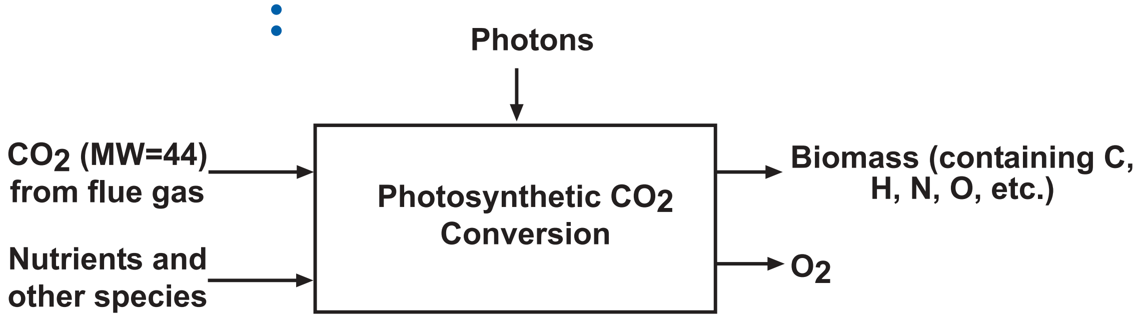
Total Project Value:	$1,369,495
DOE:	$1,075,022
Non-DOE Share:	$ 294,473

Accomplishments

- Isolated 15 unialgal cultures that show promise for growth on an artificial substrate inside a photobioreactor
- Established positive effect of Ca^{+2} on algal growth rate on artificial substrate (Omnisil screens)
- Installation of a solar light collector, fiber optic light cables and light distribution panels for the photobioreactor
- Photobioreactor design tested and improved for evaluation of large-scale biofilm placement
- Filed a patent claim titled, "Enhanced Practical Photosynthetic CO_2 Mitigation," which is about the bioreactor design and how to use it to control CO_2

Benefits

Three major benefits, in addition to CO_2 mitigation, could result from the use of this novel method of photosynthetic sequestration. The production of oxygen would be one benefit. Oxygen is a natural product of photosynthesis. The second benefit of this project would be the reduction of gaseous pollutants including potential NH_3 slip (from selective catalytic reduction to control NOx) and NOx. In terms of other pollution control, this process could provide NOx control at no additional cost. First, the flow process used to enhance soluble carbon concentration is a natural scrubber. Not only is NOx converted to nitrates, SOx is converted to sulfates and sulfites, and any NH_3 that might 'slip' through an upstream SCR process for NOx reduction will be scrubbed as well. Both NOx and NH_3 scrubbing are not only an additional benefit; such scrubbing is beneficial to photosynthesis, as the microalgae require nitrogen to grow. The third benefit would be from the production of biomass with beneficial end-uses. The resulting biomass has numerous beneficial uses. In addition to being a potential fuel, microalgae have been used as soil stabilizers, fertilizers, in the generation of biofuels, such as biodiesel and ethanol, and to produce H_2 for fuel cells. In recent tests, it also has shown suitable ignition characteristics to be co-fired with coal in pulverized coal-fired generation units.



Simple diagram of the photosynthetic conversion process of CO_2 to biomass and oxygen