

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY



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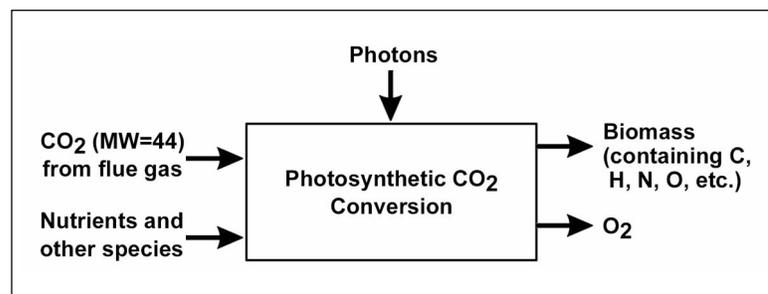
Sequestration

01/2004

ENHANCED PRACTICAL PHOTOSYNTHETIC CO₂ MITIGATION

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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ conversion to biomass, absorbing greenhouse gases. In this case, the microalgal biomass represents a natural sink for carbon.



Simple diagram of the photosynthetic conversion process of CO₂ to biomass and oxygen

CUSTOMER SERVICE

800-553-7681

WEBSITE

www.netl.doe.gov

PARTNER

Ohio University

COST

Total Project Value:

\$1,369,495

DOE/Non-DOE Share:

\$1,075,022 / \$294,473

Primary Project Goal

The main purpose of this research is to demonstrate and optimize low-risk methods of CO₂ mitigation based on existing biological organisms capable of significant CO₂ uptake and offer a valid near-term solution for the CO₂ 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 CO₂ 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.

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)
- Installed a solar light collector, fiber optic light cables and light distribution panels for the photobioreactor
- Tested and improved the Photobioreactor design for evaluation of large-scale biofilm placement
- Filed a patent claim titled, "Enhanced Practical Photosynthetic CO₂ Mitigation," which is about the bioreactor design and how to use it to control CO₂

Benefits

Three major benefits, in addition to CO₂ 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 NH₃ slip (from selective catalytic reduction to control NO_x) and NO_x. In terms of other pollution control, this process could provide NO_x control at no additional cost. First, the flow process used to enhance soluble carbon concentration is a natural scrubber. Not only is NO_x converted to nitrates, SO_x is converted to sulfates and sulfites, and any NH₃ that might slip through an upstream SCR process for NO_x reduction will be scrubbed as well. Both NO_x and NH₃ 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 H₂ 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.