PROJECT facts

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

Sequestration

12/2004

COMBINED POWER GENERATION AND CARBON SEQUESTRATION USING A DIRECT FUELCELL®

Background

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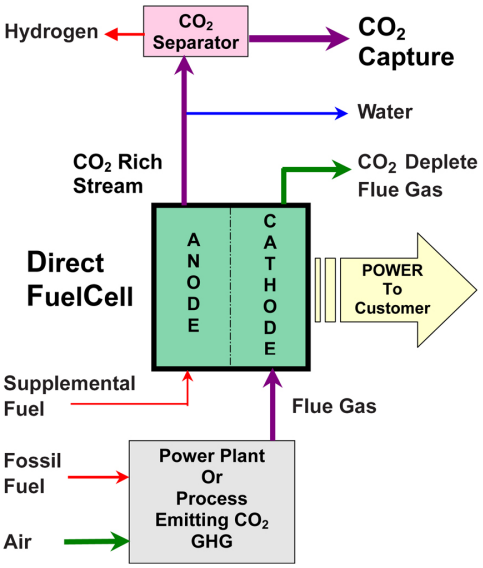
This project is responsive to the growing concern over global warming as a result of carbon dioxide emissions into the atmosphere from fossil fuel burning power plants and other industrial sources. FuelCell Energy (FCE) has developed a novel concept for the separation, capture, and potential sequestration of CO_2 emissions through the use of Direct FuelCell (DFC®) technology while concurrently generating power at high efficiency. The mitigation of the greenhouse effect through CO_2 sequestration is a new and unique application for DFC.

In the DFC, CO_2 is transferred from the cathode to the anode of the fuel cell resulting in a CO_2 rich exhaust stream, which can be sequestered. Key reactions are:

Anode: $H_2 + CO_3^{-2} \rightarrow H_2O + CO_2 + 2e^-$

Cathode: $\frac{1}{2} O_2 + CO_2 + 2e^- \rightarrow CO_3^{-2}$

Internal reforming of a hydrocarbon, such as natural gas, provides the hydrogen for the anode reaction. During normal fuel cell operation, some of the CO_2 from the anode exhaust is recycled to the cathode to form CO_3^{-2} ions that carry the current through the cell. In the concept of this project, the CO_2 is provided by passing flue gas over the cathode; and, as the fuel cell operates, the CO_2 in the flue gas is transferred from the cathode to the anode. The system will be studied to determine its effectiveness in capturing more than 90% of the carbon dioxide from the flue gas. The gain in electric power generated by the fuel cell is anticipated to result in a low net cost for carbon dioxide capture. Additionally, hydrogen from the anode exhaust may be recovered for sale or burned onsite to raise steam for a steam turbine generator.



CO_2 capturing system concept utilizing Direct FuelCell

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

PARTNERS

FuelCell Energy, Inc.

COST

Total Project Value
$171,222

DOE/Non-DOE Share
$136,978/$34,244

Benefits

One of the major problems in reducing CO_2 emissions from power plants is the high cost of recovering CO_2 from flue gas. This project is anticipated to result in a CO_2 separation and capture system based on an internally reformed DFC with potential for capturing at least 90% of GHG emissions generated by power plants and other industrial processes. The proposed system is targeted at no more than a 10% increase in the cost of electric power. If an inexpensive CO_2 capture system can be developed, then CO_2 sequestration could be practiced with minimal impact on the nation's economy.

This project will conduct the research and development essential for process optimization and cost estimation to ensure the successful implementation of the system. The design activities will be focused on integration of DFC-based CO_2 capture systems with coal-based power plants, which emit large amounts of greenhouse gases. The types of coal-fired power plants to be studied include pulverized coal (PC) fired, fluidized bed combustion, and integrated gasification combined cycle (IGCC). In parallel to the design activities, operation of a laboratory scale DFC will verify the benefits of the concept and provide input to the design activity. The anticipated result of this project is the development of a DFC-based CO_2 capture system that will increase the cost of electricity by less than ten percent.

FCE is a leading developer of DFC technology deployed for commercial power production applications. High volume manufacturing of fuel cells for power applications is projected to lower the cost of DFC based CO_2 sequestration systems. Considering that alternative technologies are energy intensive, expensive and/or complex, the efficient energy producing DFC carbon capture system is seen as a viable option for mitigating greenhouse gases from large point sources.

Primary Project Goal

The overall goal of this project is the development of a cost effective carbon separation and capture system utilizing a novel concept based on DFC technology.

Objectives

The objectives of this project are:

- To develop process design options for the integrated DFC-based CO_2 capture system to reduce GHG emissions from traditional coal-based plants, such as pulverized coal fired power plants, as well as advanced technologies, such as IGCC.
- To develop a database for various GHGs derived from coal fired power plants.
- To evaluate options for desulphurization of GHGs.
- To investigate techniques for the separation of CO_2 from the fuel cell anode exhaust.
- To perform detailed analysis using computer simulation of the DFC-based carbon capture system to verify the added benefits of simultaneous power generation and hydrogen by-product production.
- To determine the net cost of energy production after retrofitting a conventional power plant with DFC carbon capture.
- To experimentally validate simulation results and to refine equipment and cost models by conducting DFC tests in a lab-scale fuel cell using state-of-the-art fuel cell components.