FuelCell Energy
World Leader in Ultra-Clean Power

## Thrust Area: Carbon Sequestration/Separation

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To address the concerns about the greenhouse gas (GHG) effect, many development efforts are currently being focused on capture and permanent sequestration of $CO_2$. An important strategy is to reduce the emission of GHG to the atmosphere. Flue gases from coal-fueled power plants and other industrial plants contain $CO_2$ which needs to be separated and captured.

The unique chemistry of carbonate fuel cell offers an innovative approach for separation of carbon dioxide from greenhouse gases (GHG). The carbonate fuel cell system also produces electric power at high efficiencies. The simultaneous generation of power and CO2 capture suggest an attractive scenario for re-powering the existing coal-fueled power plants. Development of this system is concurrent with emergence of Direct FuelCell® (DFC®) technology for generation of electric power from fossil fuels. DFC is based on carbonate fuel cell featuring internal reforming. This technology has been deployed in MW-scale power plants and is readily available as a manufactured product. A simplified diagram of the conceived system concept for combined $CO_2$ separation (from flue gases) and power generation is illustrated in Figure 1.

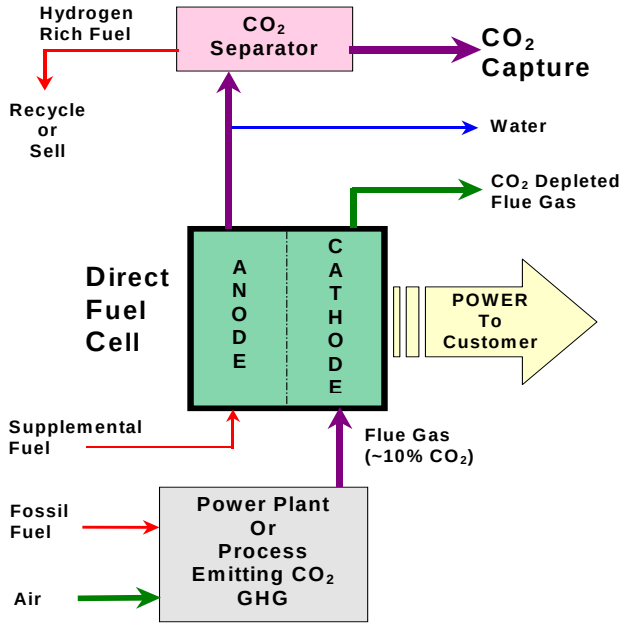


**Figure 1. Direct Fuel Cell-based $CO_2$ Separation and Power System Concept:** The system can be used with a variety of $CO_2$-containing greenhouse gases (GHG)

In this approach, $CO_2$-containing flue gas from coal-fired, combustion-based power plants, such as the exhaust from a pulverized coal (PC) power plant, is utilized as oxidant for the DFC cathode. The concept's key feature is that the DFC utilizes the $CO_2$ of the flue gas (greenhouse gas) as a reactant for the electrochemical reaction to produce power, while synergistically transferring $CO_2$ from the flue gas to the anode exhaust stream. A supplementary fossil fuel such as natural gas, propane, or syngas from a coal gasifier is

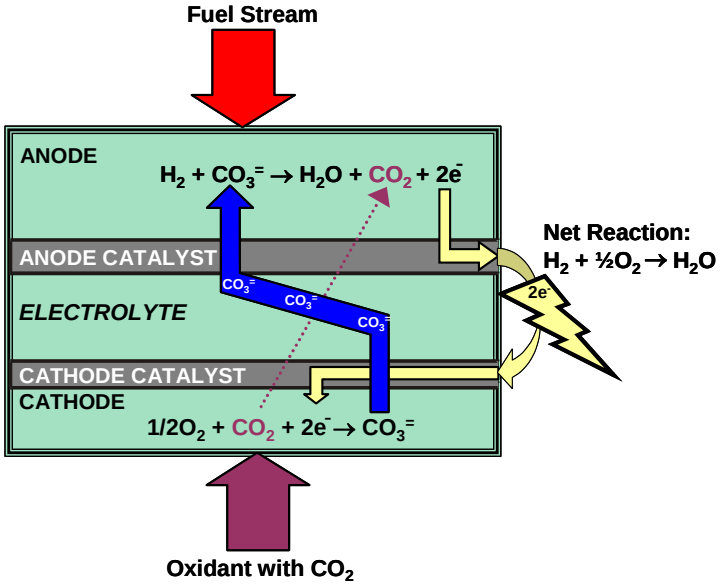


**Figure 2. Utilization of $CO_2$ in a Direct FuelCell®:**
Carbon dioxide is used at the cathode as an oxidant and transferred to the anode via the carbonate electrolyte

used as the fuel cell anode feed to provide $H_2$ (primary fuel) needed to complete the electrochemical power generation cycle. The operating principle of DFC including the mechanism for transport of $CO_2$ from the cathode to the anode of the fuel cell is shown in Figure 2. In addition to $CO_2$, $H_2O$ is produced at anode as $H_2$ is consumed by the electrochemical reaction. Overall, the operating mechanism of DFC results in the separation and transfer of $CO_2$ into the anode exhaust stream with a much-reduced flow compared to the original flue gas.

FuelCell Energy, Inc. (FCE) conducted a preliminary feasibility study to assess the DFC-based system concept for separation of $CO_2$ from GHG. The effort was funded by the US Department of Energy in a cost-shared program. Development of the DFC-based systems focused on integration of the $CO_2$ separation systems with coal-based power plants, which emit large amounts of GHG. In parallel to the system design and simulation activities, operation of laboratory scale DFC verified the technical concept and provided input to the design activity. The system was studied to determine its effectiveness in capturing more than ninety percent of CO2 from the flue gases. Cost analysis was performed to estimate the change in cost of electricity for a 200 MW pulverized coal boiler steam cycle plant retrofitted with the DFC-based $CO_2$ separation

system producing an additional 130 MW of electric power. The results of the feasibility investigation indicated the significance of synergistic generation of clean power and carbon sequestration.

Development of DFC-based $CO_2$ separation systems under this thrust area will also focus on evaluating the effects of coal flue gas contaminants on DFC performance and endurance, identifying acceptable contaminant levels for fuel cell feed, and selection or design development of the required clean-up equipment or subsystem. Funding is being sought to develop the related enabling technologies.