the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Slipstream Testing of a Membrane CO_2 Capture Process for Existing Coal-Fired Power Plants

Background

The mission of the U.S. Department of Energy/National Energy Technology Laboratory (DOE/NETL) Existing Plants, Emissions & Capture (EPEC) Research & Development (R&D) Program is to develop innovative environmental control technologies to enable full use of the nation's vast coal reserves, while at the same time allowing the current fleet of coal-fired power plants to comply with existing and emerging environmental regulations. The EPEC R&D Program portfolio of post- and oxy-combustion carbon dioxide (CO_2) emissions control technologies and CO_2 compression is focused on advancing technological options for the existing fleet of coal-fired power plants in the event of carbon constraints. This project is one of six R&D carbon capture projects from the EPEC program that were selected by DOE to receive funding from the American Recovery and Reinvestment Act of 2009 (ARRA). These projects will accelerate carbon capture R&D for industrial sources toward the goal of cost-effective carbon capture within 10 years.

Post-combustion separation and capture of CO_2 is a challenging application due to the low pressure and dilute concentration of CO_2 in the waste stream, trace impurities in the flue gas that affect removal processes, and the parasitic energy cost associated with the capture and compression of CO_2. Membrane-based capture utilizes permeable or semi-permeable materials that permit the selective separation of CO_2 from flue gas and has the potential to effectively reduce the energy penalties and costs associated with post-combustion CO_2 capture for industrial facilities, as well as for both new and existing pulverized coal (PC)-fired power plants.

Project Description

Membrane Technology and Research (MTR) and partners will demonstrate a cost-effective membrane process to separate CO_2 from coal-fired power plant flue gas at pilot-scale and will evaluate its potential in an industrial application. Membrane-based flue gas CO_2 separation technologies offer a number of advantages, including low energy use, tolerance to wet acid gases, small footprint, recovery of flue gas water, and—as they use only electric power—no modifications to the existing boiler and steam turbine. However, due to the low partial pressure of CO_2 in flue gas, membrane-based processes require a large membrane area for separation. The MTR innovative membrane design addresses this problem by utilizing two key innovations: high CO_2 permeance membranes and a countercurrent sweep module design. MTR's Polaris™ membranes have ten times the CO_2 permeance of conventional gas separation membranes, which leads to a tenfold decrease in the required membrane area and reduces the capital cost and footprint of the capture system substantially. The counter-current sweep module design utilizes an existing air stream to generate a driving force for CO_2 capture, reducing the need for compressors or vacuum pumps. These innovations allow the membrane process to capture CO_2 from flue gas with substantial cost reductions.

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PARTNERS

Arizona Public Services
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Electric Power Research Institute, Inc.

PERFORMANCE PERIOD

Start Date	End Date
10/01/2010	09/30/2015

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U.S. DEPARTMENT OF ENERGY

COST

Total Project Value

$18,750,000

DOE/Non-DOE Share

$15,000,000 / $3,750,000

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

AWARD NUMBER

DE-FE0005795

In a previous DOE project, MTR demonstrated bench-scale performance of their high permeance CO_2 membranes with flue gas mixtures and the effective operation of countercurrent sweep modules. Field work, at a 0.05 MWe level, was performed to test 8-inch diameter modules with small slipstreams of flue gas from gas and coal-fired power plants. This project will demonstrate a 1 MWe membrane system using full-scale membrane components (12-inch diameter modules) on a slipstream of coal-fired power plant flue gas.

Goals

The overall goal of this project is to build a 1 MWe (20 ton CO_2 per day) membrane CO_2 capture system and operate it on a slipstream of flue gas at a coal-fired power plant. The demonstration system will assist in validating the potential of the MTR process to capture at least 90 percent of the CO_2 from coal-fired flue gas while meeting the DOE target of less than a 35 percent increase in the cost of electricity (COE).

Objectives

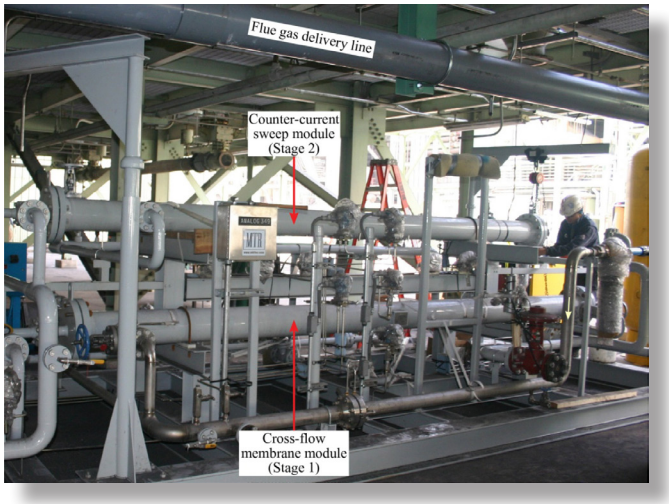
The project objectives are to (1) optimize membrane performance, module pressure drop, and module fouling resistance; (2) design and construct a membrane system for 1 MWe-scale flue gas slipstream testing; (3) conduct a six-month field test of the 1 MWe membrane system; (4) analyze the performance of the membrane system, determine how it would be best integrated with an electric power plant, and prepare a comparative study of the membrane-based CO_2 capture process versus other capture technologies; (5) determine the impact of recycle air on boiler performance; and (6) evaluate the membrane potential in an industrial application.

Planned Activities

- Continue operation of existing 0.05 MWe system to optimize membrane materials and module designs.
- Design, construct, and install the 1 MWe membrane skid at a coal-fired power plant.
- Conduct a six-month field test of the 1 MWe membrane system.
- Evaluate the air sweep process design to determine the performance impact of retrofitting existing boilers.
- Evaluate the benefits of flue gas water recovery, measure the quality of the water produced in the demonstration project, and define water management for the integrated CO_2 capture process.
- Relocate and test the 0.05 MWe system at the National Carbon Capture Center to validate its performance, expose the membrane to different coal types, and test CO_2 liquefaction at a small scale.
- Update the comparative economic analysis with results from the 1 MWe test program to clarify the potential of the membrane process and identify key cost-reduction milestones and success criteria.
- Evaluate the potential application of the membrane system for an industrial facility.

Accomplishments

- Project awarded in September 2010.
- Kick-off Meeting conducted in October 2010.



A picture of MTR's 1 ton/day CO_2 capture test system at the APS Cholla power plant.

Benefits

The demonstration and further validation of this innovative, cost-effective membrane process to separate CO_2 from coal-fired power plant flue gas at the 1 MWe pilot scale can be a major step toward meeting DOE's program goals of capturing more than 90 percent of the CO_2 from flue gas with less than a 35 percent increase in the COE. Compared to previous membrane designs considered for flue gas CO_2 capture, the MTR process with countercurrent sweep uses lower energy and less membrane area. This project will provide sufficient performance data to allow a thorough technical and economic evaluation of the membrane capture process and will clarify the relative potential of this approach for industrial- and utility-scale processes. Successful completion of this program can signify readiness to proceed to the next step of testing a larger 10 to 25 MWe system that includes CO_2 liquefaction and sequestration.