the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

CO_2 Capture Membrane Process for Power Plant Flue Gas

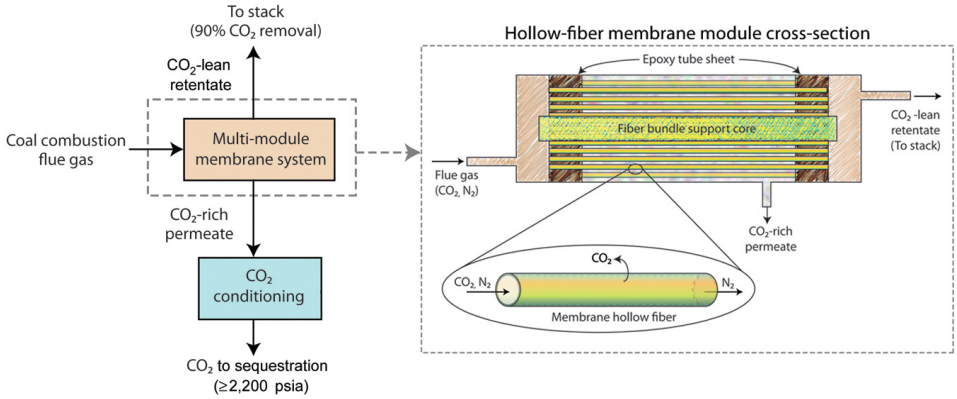
Background

The U.S. Department of Energy's (DOE) Existing Plants, Emissions & Capture (EPEC) Program is performing research to develop advanced technologies focusing on carbon dioxide (CO_2) emissions control for existing pulverized coal-fired plants. This new focus on post-combustion and oxy-combustion CO_2 emissions control technology, CO_2 compression, and beneficial reuse is in response to the priority for advanced technological options for the existing fleet of coal-fired power plants in the event of carbon-constraints.

Pulverized coal (PC) plants burn coal in air to raise steam and comprise 99% of all coal-fired power plants in the United States. CO_2 is exhausted in the flue gas at atmospheric pressure and a concentration of 10-15 volume percent. "Post-combustion" 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 (Nitrogen Oxides [NO_x], Sulfur Oxides [SO_x], particulate matter [PM]) that affect removal processes, and the parasitic load associated with the capture and compression of CO_2.

Description

As part of the effort to develop post-combustion CO_2 emissions control technologies, RTI International is leading a research team to develop and integrate a polymer membrane-based process for capturing flue-gas CO_2 from existing PC power plants. Broadly, the project will focus on new, high-performance membrane materials, improved hollow-fiber membrane module design, and process development for cost-effectively



RTI's CO_2 capture membrane process and hollow-fiber membrane module design.

CONTACTS

Jared P. Ciferno
Technology Manager
Existing Plants, Emissions & Capture
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-5862
jared.ciferno@netl.doe.gov

José D. Figueroa
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4966
jose.figueroa@netl.doe.gov

Lora Toy
Project Manager
RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709-2194
919-316-3393
ltoy@rti.org

PARTNERS

RTI International
Generon IGS, Inc.
Arkema Inc.

PERIOD OF PERFORMANCE

10/01/2008 to 09/30/2010

COST

Total Project Value
$2,431,027

DOE/Non-DOE Share
$1,944,821 / $486,206

NATIONAL ENERGY TECHNOLOGY LABORATORY

Albany, OR • Morgantown, WV • Pittsburgh, PA

Website: www.netl.doe.gov

Customer Service: 1-800-553-7681

U.S. DEPARTMENT OF ENERGY

retrofitting a CO_2 capture membrane system into coal plants. New fluoropolymer chemistries and microstructures will be developed as improved CO_2 capture membrane materials by leveraging the polymer synthesis and engineering expertise of project partner Arkema. Improved membrane hollow fibers and membrane modules for CO_2 capture will be developed and fabricated by project partner Generon from the next generation of their baseline membrane. Membrane process engineering design and integration strategies will be developed by RTI to identify optimum process operating conditions and guide the membrane materials and module research and development efforts. RTI will also evaluate the separation performance of new polymers, membrane hollow fibers, and membrane modules with simulated flue gas with and without flue gas contaminants (SO_2, NO_x) in the laboratory and with a flue-gas slipstream from the U.S. Environmental Protection Agency's (EPA's) coal-fired combustion unit in Research Triangle Park, NC.

Primary Project Goal

The primary goal of this project is to develop an advanced polymeric membrane-based process that can be cost-effectively, easily, and reliably retrofitted into existing PC power plants to separate and capture at least 90% of the CO_2 from the plant's flue gas at 50-60 °C, with no more than a 35% increase in cost of electricity (COE).

Objectives

Specific project objectives include:

- To develop two or three new chemistries/structures of fluorinated polymer membrane materials that have (i) excellent chemical stability to moisture and SO_2 and NO_x contaminants present in flue gas; (ii) high selectivity for CO_2 over N_2 [30-50 selectivity targeted]; and (iii) high permeance to CO_2 [3×10^{-4} to 3×10^{-3} $cm^3(STP)/(cm^2\cdot s\cdot cmHg)$ targeted]
- To identify candidate membrane process design(s) for integrated CO_2 capture in PC plants and more definitive membrane CO_2 permeance and selectivity targets for a viable process through process simulations
- To fabricate polymer candidate(s) into defect-free membrane hollow-fibers with high CO_2/N_2 selectivity and high CO_2 permeance
- To fabricate field-test membrane modules from membrane hollow fibers
- To demonstrate CO_2 capture performance and reliability of membrane modules in a field test with real coal-fired process flue gas

Benefits

This project could provide PC power plants with a cost-effective membrane process technology option for controlling flue-gas CO_2 emissions and, thus, aiding in greenhouse gas mitigation. Membrane processes for CO_2 capture are advantageous because they are simple and can be integrated downstream of existing flue-gas cleanup systems (i.e., the flue-gas desulfurization unit) in coal plants without requiring modification of major plant infrastructures, such as fuel processing, boiler, and steam turbine subsystems. Compared to regenerable, adsorption- and absorption-based CO_2 capture approaches (i.e., solid sorbents and liquid solvents), membrane processes are more attractive in that no parasitic adsorption or absorption losses due to heat required to regenerate and release CO_2 from the spent sorbent or solvent are associated with their operation. Given the relative compactness and simple operation of the membrane process, it is anticipated that the technology can fit both niche and large-scale CO_2 separation applications. The membranes' modular design allows for use as a single module or several hundred modules depending on the scale of the CO_2 removal required. Overall, this technology should expand the options utility companies have to produce electrical power in a carbon-constrained world.

Milestones

- **Q4 FY2009:** Baseline CO_2 separation performance data on laboratory-scale membrane modules made from Generon's standard commercial membrane hollow fibers.
- **Q4 FY2009:** Identification of CO_2 capture membrane process system design option(s) and their process flow scheme(s).
- **Q3 FY2010:** 300 hours of field testing of CO_2 capture membrane test skid with real coal-fired flue gas.
- **Q4 FY2010:** Techno-economic evaluation of "best" integrated/retrofitted CO_2 capture membrane process package.

Planned Activities

Activities are focused on fabrication of baseline membrane modules, evaluation of the CO_2 separation properties of these modules, and investigation of different process design flow schemes to identify promising process design configurations. Future work will focus on fabricating and field-testing polymer candidate(s) into defect-free membrane hollow-fibers with high CO_2/N_2 selectivity and high CO_2 permeance.