the ENERGY lab

PROJECT FACTS

Advanced Research

Field Demonstration of CO_2 Capture from Coal-Derived Syngas

Background

Evidence suggests that man-made emissions of greenhouse gases, principally carbon dioxide (CO_2), are contributing to global climate change. A significant portion of these CO_2 emissions are caused by the combustion of fossil fuels. One approach to controlling CO_2 emissions from fossil fuel power plants is carbon capture and sequestration (CCS). In this scheme, CO_2 is captured from large point sources, such as power plants, and permanently sequestered underground in geologic structures. A key to this approach is technology that can separate CO_2 from process gases cost-effectively, allowing CO_2 to be sequestered without radically increasing energy costs.

Three pathways are being considered by the Department of Energy (DOE) for CO_2 capture from fossil fuel power production: post-combustion CO_2 capture from flue gas, pre-combustion capture from synthesis gas (syngas), and oxy-combustion, which produces a nearly sequestration-ready CO_2 effluent. This project, headed by Membrane Technology and Research, Inc. (MTR), is focused on improving the cost and efficiency of pre-combustion carbon dioxide capture from syngas.

The project is funded as part of the DOE Phase III Xlerator program. The project will build on the DOE's existing efforts under the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) Programs. The award will provide MTR with the staying power needed to develop the processes that are necessary to reduce the manufacturing costs for their product and enable manufacturing at scale. Overcoming cost and scale challenges is critical for small businesses to successfully bring their ideas to the marketplace.

Project Description

This project will develop a membrane-based process that can separate water-gas shifted coal-derived syngas into hydrogen and high-pressure liquid CO_2 ready for geologic sequestration. In this project, the process will be proven in a field test treating 500 lb/hr raw syngas (equivalent to 0.1 MWe IGCC syngas).

Membrane processes based on hydrogen-selective and CO_2-rejecting membranes have previously been suggested as as a means to lower the cost and energy intensity of IGCC syngas cleanup. Much of this effort has focused on inorganic membranes and thermally stable polymers, because of the desirability of operating at higher temperatures. Membranes of this type offer the potential of process intensification in syngas cleanup by combinining water-gas shift reactions with hydrogen separation. In addition, hydrogen-selective membranes can use nitrogen from the gasifier's air separation unit as a sweep gas to increase the driving force for hydrogen separation without reducing the pressure of the H_2-enriched permeate stream.

CONTACTS

Robert Romanosky
Advanced Research
Technology Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880 PO3D
Morgantown, WV 26507-0880
304-285-4721
robert.romanosky@netl.doe.gov

Meghan Napoli
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880 PO3B
Morgantown, WV 26507-0880
304-285-5255
meghan.napoli@netl.doe.gov

Haiqing Lin
Principal Investigator
Membrane Technology and Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025-1516
650-543-3359
haiqing.lin@mtrinc.com

PARTNERS

National Carbon Capture Center/
Southern Company

PERFORMANCE PERIOD

Start Date
10/01/2010

End Date
09/30/2012

COST

Total Project Value

$1,499,129 + $300,000 commercial contribution from MTR

DOE/Non-DOE Share

$1,499,129 / $300,000

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

AWARD NUMBER

DE-FE0006138

MTR has evaluated various membrane process designs for hydrogen purification and CO_2 capture from IGCC syngas, and found that the optimum IGCC pre-combustion capture membrane system would use hydrogen-selective membranes for bulk hydrogen recovery in combination with CO_2-selective membranes for CO_2 purification and liquefaction.

MTR's CO_2-selective membranes (Polaris™) were studied during the previous DOE SBIR Phase I/II program (DE-FG02-04ER83999; 2005-2008), which brought the technology from the lab to the small-scale field trial stage. The Polaris™ polymer-based membrane modules have been tested in the field and were stable and reliable for up to 500 hours (hr) of continuous operation with real coal-derived syngas. The separation process is now ready for a pilot-scale demonstration and a complete pilot-scale unit will be built and tested that will produce both purified H_2 and high-pressure liquid CO_2 for sequestration. The demonstration skid will be operated at the National Carbon Capture Center (NCCC), using a real syngas stream provided by Southern Company.

After MTR delivers the membrane process skid to the NCCC facility and goes through shakedown operations, the membrane system will run for 1,000 hours, treating 500lb/hr of raw syngas from NCCC/Southern's coal-fired gasification plant. The data from this test will be used to optimize membrane system design and improve process integration with IGCC power plants. Low-cost membrane system components will be designed and evaluated for potential use in future large-scale CO_2 capture systems. Finally, process designs optimizing the integration of the CO_2-selective Polaris™ membranes with high-temperature H_2 -selective membranes will be prepared.

Goals/Objectives

The goal of this project is to conduct a pilot-scale field test of a membrane process that can separate shifted syngas into H_2 and high-pressure liquid CO_2 ready for sequestration. This is the first step in adopting energy-efficient membrane technology for CO_2/H_2 separations. If successful, the eventual use of this low-cost, environmentally benign membrane technology has the potential to substantially improve the economics of IGCC power production.

Accomplishments

In the first six months of the project, the major accomplishment has been production and testing of industrial composite membranes with promising CO_2 separation properties. Preparation has also begun for an initial small-scale field test at NCCC/Southern in May 2011, using the unit shown in the accompanying photo.

MTR's current 50 lb/hr syngas test skid at NCCC. The Phase III test skid being built for operation in 2012 will demonstrate that the process works at ten times this feed volume.

Benefits

This project will pave the way for adopting energy-efficient membrane technology for CO_2/H_2 separations. The eventual use of low-cost, environmentally friendly membrane technology has the potential to substantially improve the economics of IGCC power production while providing CO_2 capture. By doing so, it will enable the use of coal, of which the United States has the world's largest reserves, as a more environmentally responsible future source of energy and chemical production.