the ENERGY lab

PROJECT FACTS

Carbon Capture

Development of Mixed-Salt Technology for Carbon Dioxide Capture from Coal Power Plants

Background

The mission of the U.S. Department of Energy/National Energy Technology Laboratory (DOE/NETL) Carbon Capture Research & Development (R&D) Program is to develop innovative carbon dioxide (CO_2) emissions control technologies for fossil fuel-based power plants. The Carbon Capture R&D Program portfolio of pre- and post-combustion CO_2 emissions control technologies and related CO_2 compression is focused on advancing technological options for new and existing power plants to enable cost-effective CO_2 capture for beneficial use or storage of CO_2 and ensure that the United States will continue to have access to safe, reliable, and affordable energy from fossil fuels. The DOE FE/NETL goal is to demonstrate second-generation technologies that can capture 90 percent of the CO_2 at less than $40 per metric ton (tonne) in the 2020-2025 timeframe. DOE is also committed to extend R&D support to even more advanced transformational carbon capture technologies that will increase competitiveness of fossil based energy systems beyond 2035.

Post-combustion CO_2 capture technologies are applicable to conventional pulverized coal (PC)-fired power plants, where the fuel is burned with air in a boiler to produce steam that drives a turbine generator system to produce electricity. The CO_2 is exhausted in the flue gas at atmospheric pressure and a concentration of 10–15 percent by volume. Post-combustion separation and capture of CO_2 is a challenging application due to the low driving force resulting from 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. Carbon capture technologies developed by the DOE program may also be applied to natural gas power plants after addressing the R&D challenges associated with the relatively lower concentration of CO_2 in the flue gas (typically 3–4 percent) of natural gas plants. A novel mixed-salt solvent technology displays several advantages that have potential to significantly reduce CO_2 capture cost.

Project Description

SRI International (SRI), in collaboration with its partners, will test at bench scale a novel ammonia-based mixed-salt solvent process with the potential to meet DOE's CO_2 capture cost goals. The mixed-salt technology combines existing ammonium and potassium carbonate technologies with improved absorption steps for rate enhancement and a novel selective regeneration process. SRI leveraged knowledge of existing ammonia-based and potassium-based processes to develop a highly efficient mixed-salt process that capitalizes on the advantages of both ammonia- and potassium-carbonate-based technologies and eliminates the disadvantages associated with

CONTACTS

Michael Matuszewski
Carbon Capture Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-5830
michael.matuszewski@netl.doe.gov

Steven Mascaro
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-0202
steven.mascaro@netl.doe.gov

Indira Jayaweera
Principal Investigator
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025
650-859-4042
indira.jayaweera@sri.com

PARTNERS

OLI Systems, Inc.
Stanford University
Politecnico di Milano
Aqueous Solutions Aps

PROJECT DURATION

Start Date	End Date
10/01/2013	03/31/2016

COST

Total Project Value
$2,121,742

DOE/Non-DOE Share
$1,697,647/$424,095

PROJECT NUMBER

DE-FE0012959

U.S. DEPARTMENT OF ENERGY

the individual processes. The advantages of this process include low heat of reaction, high CO_2 loading, high-pressure regeneration of more than 99 percent pure dry CO_2, low sensitivity to impurities, low process cost, use of a non-degradable low-cost solvent with a very low carbon footprint, low emissions, and reduced water use compared to conventional ammonia-based technologies. Prior laboratory-scale testing and extensive equilibrium modeling work at SRI showed potential for the mixed-salt process to meet the DOE carbon capture cost and performance goals. This effort will advance the technology from the current laboratory scale to a bench-scale level. The bench-scale testing will be conducted at SRI's test site in Menlo Park, CA, using simulated PC-fired flue gas.

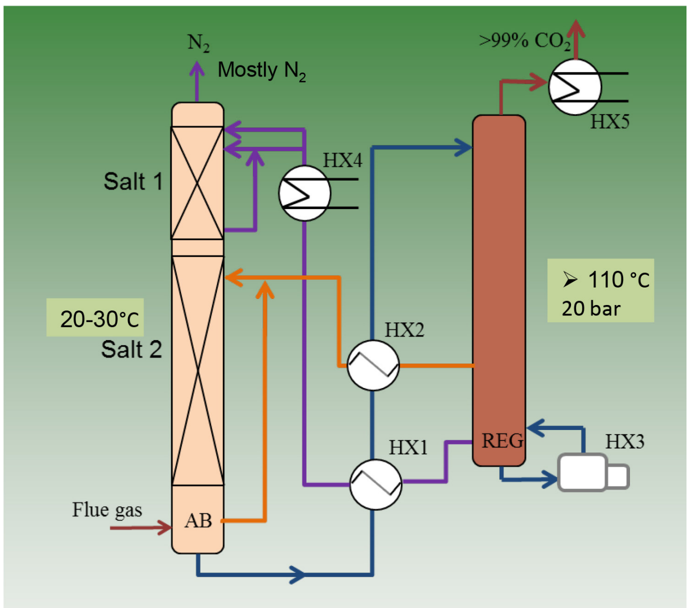

Diagram of the mixed-salt process.

The mixed-salt technology uses a two-stage absorber system. To improve the process performance and reduce the cost, the absorber conditions will be optimized using two individual absorbers before testing a single two-stage absorber. The project team will optimize process kinetics, reduce ammonia emissions, and improve the current models for realistic techno-economic assessments. Data from previous laboratory-scale tests will be used to design, install, and test an approximately 100-kilowatt size bench-scale absorber system. The research team will develop a rate-based process-modeling database and conduct a techno-economic evaluation of the mixed-salt process to determine the cost associated with integrating a CO_2 capture system based on mixed-salt technology into a 550-megawatt electrical (MWe) power plant. The mixed-salt solvent process is anticipated to achieve greater than 50 percent reduction in parasitic power demand compared to conventional monoethanolamine technology, a 90 percent reduction in water use compared to the chilled-ammonia process, and significant reductions in capital, operating, and maintenance costs.

Primary Project Goal

The goal of this project is to develop and test at bench scale a novel ammonia-based, mixed-salt solvent technology for post-combustion CO_2 capture to validate that the process can advance the DOE goal to demonstrate second-generation technologies that can capture 90 percent of the CO_2 at less than $40 per metric ton (tonne) in the 2020–2025 timeframe.

Objectives

The project objectives are to optimize the mixed-salt process performance at a bench-scale level to reach 90 percent CO_2 capture with reduced ammonia emissions, low water usage, and high-pressure CO_2 regeneration; determine the independent relationships among solvent concentration, absorption, and regeneration conditions, column packing, CO_2 capture efficiency, cyclic capacity, ammonia loss, and water usage; establish a rate-based thermodynamic modeling database for the ammonium- and potassium-based system; and complete an environmental, health, and safety (EH&S) analysis and a techno-economic assessment for integration of the mixed-salt technology in a 550 MWe PC-fired power plant.

Planned Activities

- Design and assemble a bench-scale test unit in which to conduct absorption and regeneration experiments
- Develop test plans and conduct parametric individual absorber and regenerator tests in a semi-continuous mode
- Conduct preliminary and advanced process modeling
- Design and construct a bench-scale continuous, integrated test system to run on a simulated flue gas stream
- Develop a test plan and conduct parametric, bench-scale, continuous integrated absorber-regenerator testing
- Perform final process modeling, a techno-economic analysis, and a technology EH&S risk assessment

Accomplishments

The project kick-off meeting was held in December 2013.

Benefits

SRI's mixed-salt solvent-based process for CO_2 capture has the potential to achieve over 50 percent reduction in parasitic power demand compared to conventional monoethanolamine technology with a 90 percent reduction in water use compared to the chilled-ammonia process. This will result in significant reductions in capital, operating, and maintenance costs and make progress toward enabling cost-effective control of CO_2 emissions from coal-powered plants.