the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Low-Energy Solvents for CO_2 Capture Enabled by a Combination of Enzymes and Ultrasonics

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.

Pulverized coal (PC) plants burn coal in air to produce steam and comprise 99 percent 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 to 15 percent by volume. 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 CO_2 capture and compression. Solvent-based CO_2 capture involves selective chemical or physical absorption of CO_2 from flue gas into a liquid solvent and the recovery of the CO_2 from the solvent. Although this method is used commercially to remove CO_2 from industrial gases, it has not been applied to the removal of CO_2 from large volumes of coal-fired power plant flue gas due to significant cost and efficiency penalties. The development of solvent-based processes with low energy requirements and high capture efficiencies are a key research focus.

Project Description

Novozymes North America, Inc. (Novozymes) has teamed with the University of Kentucky, Doosan Power Systems, Ltd., and Pacific Northwest National Laboratory (PNNL) to design, build, and test an integrated bench-scale CO_2 capture system that combines the attributes of the bio-renewable enzyme catalyst carbonic anhydrase (CA) with low-enthalpy absorption liquids and novel ultrasonically-enhanced regeneration. This unique CO_2 capture system is expected to achieve improved efficiency, economics, and sustainability in comparison with existing CO_2 capture technologies.

The capture process will use a potassium carbonate solvent with low regeneration energy coupled with CA as a catalyst to promote higher rates of absorption in the

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PARTNERS

University of Kentucky
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PERFORMANCE PERIOD

Start Date	End Date
10/01/2011	12/31/2014

COST

Total Project Value
$2,088,643

DOE/Non-DOE Share
$1,658,619 / $430,024

AWARD NUMBER

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U.S. DEPARTMENT OF ENERGY

carbonate solution. The application of ultrasonic energy forces dissolved CO_2 into gas bubbles, thereby increasing the overall driving force of the solvent regeneration reaction. Additionally, through ultrasonics, a coupled effect of rectified diffusion is also believed to have the potential to drive dissolved CO_2 into gas bubbles at pressures greater than the equilibrium pressure for CO_2 over the solution. The combination of these synergistic technologies is projected to reduce the net parasitic load to a coal-fired power plant by as much as 51 percent compared to conventional monoethanolamine (MEA) scrubbing technology.

The project team will build on previous laboratory tests of the novel solvent and CO_2 recovery technique to obtain additional laboratory data sufficient to design a bench-scale system and perform a final analysis of the technology. This bench-scale study will validate the potential of the system to provide a low cost of energy solution for post-combustion CO_2 capture.

Project Goal

The overall project goal is to further develop a solvent-based post-combustion CO_2 capture technology and verify its ability to significantly reduce parasitic energy requirements and make significant progress toward meeting DOE cost and efficiency targets.

Objectives

The project objectives are to advance the novel capture technology through design, integration, and testing at bench-scale using best-candidate components from prior research by (1) obtaining sufficient laboratory data to fully support an analysis of the technology being developed; (2) performing bench-scale pilot work that will prove and refine the earlier analyses and confirm the suitability of the CA catalyst; (3) fully evaluating the technical and economic suitability of the process, including a commercial design and cost estimate; and (4) utilizing the pilot data to refine the technical analysis, update the commercial plant design and costs and identify environmental, health, and safety (EH&S) issues.

Clamp-on acoustic reactors installed on small and large stainless steel tubing.

Planned Activities

- Measure and collect remaining laboratory data needed to design the bench-scale system.
- Conduct an initial technical and economic feasibility study.
- Design, build, and perform shakedown testing of bench-scale unit components.
- Complete construction and shakedown testing of integrated bench-scale system.
- Conduct bench-scale parametric testing and monitoring.
- Complete an EH&S risk assessment.
- Finalize technology and cost assessment based on project data.

Accomplishments

- Project kick-off meeting held in November 2011.

Benefits

Successful completion of this project will result in significant progress toward reducing the monetary cost and efficiency penalties incurred with currently available CO_2 removal and recovery technologies when used on PC-fired boilers. The net effect is progress toward DOE's goal of limiting electricity cost increases due to CO_2 emissions control to 35 percent, while capturing at least 90 percent of the CO_2 from the flue gas. It is anticipated that the proposed system will be able to be incorporated into existing coal-fired plants without major obstacles, providing a viable route for enabling CO_2 emissions reductions while keeping coal a major energy resource.