the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Post-Combustion CO_2 Capture for Existing PC Boilers by Self-Concentrating Amine Absorbent

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 generate 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 10–15 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 the capture and compression of CO_2. Chemical solvents can be used to capture CO_2 from flue gas by absorbing it into a liquid carrier. Although this method is used commercially to remove CO_2 from industrial gases, it has not been applied to the removal of large volumes of gas, as in coal-fired power plant flue gas, due to significant cost and efficiency penalties.

Project Description

3H Company (3H) is leading an integrated process team to conduct research using their innovative and proprietary Self-Concentrating Amine Absorbent CO_2 Capture Process to reduce the cost and increase the efficiency of CO_2 capture from coal-fired power plant flue gas. The technology removes CO_2 from power plant flue gas using an amine absorbent and a matched non-aqueous solvent that, when reacted with CO_2, rapidly forms two distinct liquid phases: a CO_2-rich liquid phase and a dilute lean phase. Only the CO_2-rich phase will then undergo regeneration to remove the CO_2 and to recycle the solvent. Regeneration of this significantly smaller liquid volume, as well as the lower heat capacity and heat of vaporization of the non-aqueous solvent, reduces the energy requirements for the self-concentrating capture process. The technology will potentially reduce the energy penalty associated with regeneration compared to conventional monoethanolamine (MEA)-based processes and increase the amine CO_2 absorption rate. Preliminary experimental data shows that the self-concentrating capture process has the potential of reducing the total regeneration energy by as much as 70 percent.

Goal

The project goal is to develop a cost effective, solvent-based post-combustion process for CO_2 capture by experimentally and analytically confirming the feasibility of the 3H Self-Concentrating Absorbent CO_2 Capture Process to achieve at least 90 percent

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PERIOD OF PERFORMANCE

Start Date	End Date
04/01/2011	09/30/2013

COST

Total Project Value
$3,484,770

DOE/Non-DOE Share
$2,737,272 / $747,498

AWARD NUMBER

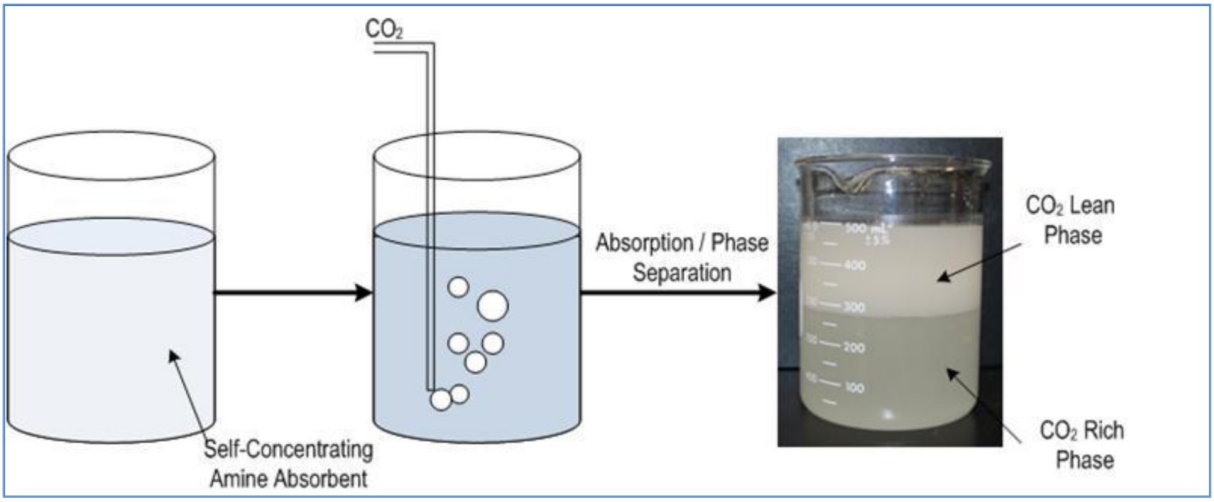
DE-FE0004274

U.S. DEPARTMENT OF ENERGY

CO_2 removal with no more than a 35 percent increase in cost of electricity (COE). Efforts will be focused toward developing a sound engineering design, supported by laboratory data and economic justification, for future construction and operation of a slipstream facility at a LG&E and KU Energy LLC power plant as the next stage of technology development.

Objectives

Project objectives are to review the current technology status and perform additional bench-scale screening to select at least one absorbent/solvent pair for detailed characterization and testing; to develop a basic theoretical and mechanistic understanding of the process; to perform pilot plant testing to generate design parameters and process requirements; and to create parallel techno-economic plant design packages for both the 3H process and a benchmark MEA process.



Concept of the Proposed Self-Concentrating Amine Absorbent Process.

Planned Activities

- A design basis document will be prepared for a coal-based power plant with post-combustion CO_2 capture. Two conceptual plant designs will be established: a 30 percent MEA design to be used for benchmarking and a conceptual design of the self-concentrating absorbent process based on available experimental data. The preliminary process design will be continuously updated throughout the project, and the economics re-evaluated as more experimental data becomes available.
- Current technology status and existing data of the CO_2 capture process will be reviewed and assessed.
- Laboratory bench-scale screening will be performed to identify at least four promising absorbents, which will then be down-selected to one or two promising absorbent/solvent pairs for bench-scale column testing.
- Basic theoretical and mechanistic understanding of the process will be developed, and simulation modeling will be performed to gain fundamental insight into the process.
- Based on the data collected, an absorption and regeneration column bench-scale pilot plant will be designed and constructed to demonstrate the concept under steady-state, multi-stage-contacting conditions.
- Pilot plant testing will be performed to examine various design and operational factors that will influence the CO_2 capture efficiency in a column.
- Based on testing results, a final process design and cost estimate for a slipstream-scale pilot plant will be prepared. A techno-economic feasibility evaluation will be completed and recommendations for future work will be provided.

Accomplishments

- Kick-off Meeting conducted in May 2011.

Benefits

Further development of 3H's innovative Self-Concentrating Amine Absorbent CO_2 Capture Process will make effective progress toward reducing the cost of CO_2 capture from coal-fired power plant flue gas and meeting DOE's cost and efficiency goals. The self-concentrating absorbent process has lower energy requirements than the conventional amine CO_2 capture process and has demonstrated increased CO_2 absorption rates as well. As the basic flow scheme of 3H's self-concentrating absorbent process is similar to that of a 30 percent MEA process, lessons learned and experience gained from MEA retrofit and integration can be directly applied to the 3H process.