the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Novel Solvent System for CO_2 Capture

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 10–15 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 (nitrogen oxides [NO_x], sulfur oxides [SO_x], and particulate matter [PM]) that affect removal processes, and the parasitic energy cost associated with the capture and compression of CO_2.

Solvent-based CO_2 capture involves chemical or physical sorption of CO_2 from flue gas into a liquid carrier. Although solvent-based systems are used commercially to remove CO_2 from industrial gases, they have 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.

Description

ION Engineering, in collaboration with its partners, will design, construct, operate, and evaluate a bench-scale CO_2 capture system using simulated flue gas at ION Engineering's laboratories. The project will demonstrate ION's innovative solvent approach for amine-based CO_2 capture, using amines as chemical solvents with ionic liquids (IL) as the physical solvent. ION's IL-amine solvent system is related to well-understood aqueous amine solvent-based processes in that it utilizes proven amines as chemical solvents for CO_2 capture; however, it differs significantly with the use of an IL rather than water as the physical solvent. Because ILs do not incur the high energy penalties of an aqueous system, utilizing ILs in place of water can significantly reduce energy requirements compared to aqueous amine systems. Higher CO_2 loading capacities can also be achieved by selectively balancing the amines and ILs.

The 18-month project will demonstrate the ability of the IL-amine solvent system to capture CO_2 using a 1.0 gallon per minute (gpm) bench-scale process unit, and will include simulation modeling to finalize process designs, laboratory evaluations,

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PARTNERS

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PERFORMANCE PERIOD

Start Date	**End Date**
10/01/2010	03/31/2012

COST

Total Project Value
$3,736,936

DOE/Non-DOE Share
$2,798,106 / $938,830

AWARD NUMBER

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solvent selection, and scale-up from the existing laboratory units to the bench-scale process unit. Design, construction, installation, integration, operation, monitoring, and decommissioning of the bench-scale unit will be performed, as well as commercial and operational assessments of the technology's ability to perform at full-scale. Project success will advance the achievement of DOE's goals of 90 percent CO_2 capture with less than a 35 percent increase in the cost of electricity (COE) with a viable retrofit solution for existing coal-fired power plants.

Project Goals

The overall project goals are to demonstrate ION's IL-amine solvents and CO_2 capture process design at a bench-scale level using simulated coal-fired power plant flue gas, to evaluate process improvements to reduce costs, and to further evaluate the ability to achieve DOE cost and performance targets at commercial scale.

Objectives

Process design objectives are to evaluate key parameters for the design of a 1.0 gpm CO_2 capture unit through laboratory work, process modeling, and performance tests. Economic analysis objectives are to develop an estimate for the potential impact of ION's solvent on the COE at scale for comparison to other technologies in use and under development.

Planned Activities

Phase 1

- Laboratory testing will be conducted on ION solvents to characterize vapor-liquid equilibrium and the requisite physical and chemical properties of the solvents for simulation modeling and process design.
- A process simulation model will be selected and customized to more effectively represent unique characteristics of ionic liquid and amine solvents versus current models.
- A laboratory-scale continuous process unit will be fabricated and used for tests with simulated flue gas to validate solvent performance and calibrate the simulation model.

Phase 2

- An optimum solvent will be selected based on viscosity, reactivity, degradation, CO_2 solubility, as well as other physical and thermal properties.
- The simulation model will be refined for specific solvent physical properties.
- Solvent performance will be validated using both simulation software and laboratory pilot test unit.
- An estimate will be developed of the potential impact of ION's solvent on the COE metric for use in comparison of ION's technology to other technologies in use and under development.

Accomplishments

- Kick-off Meeting conducted in November 2010.
- Demonstration that IL-amine solvents successfully absorb and desorb CO_2 in laboratory and continuous process tests.
- Construction and successful operation of the laboratory pilot test unit.
- Development of the IL solvent-specific simulation model.
- Phase I completed May 2011.

Benefits

The solvent technology developed by ION Engineering has potential to make significant progress toward the DOE cost and performance goals. IL-amine solvent mixtures offer a considerable reduction in regeneration energy requirements, higher CO_2 capacities, reduced corrosion, and reduced solvent losses when compared to traditional aqueous amine technologies. Technical risk is minimized with the use of proven process designs based on absorber-regenerator processes in amine capture systems. In addition, the characteristics of ION's solvent mixtures provide further opportunities to lower capital costs due to smaller footprint and lower cost materials of construction as the technology is scaled for commercial use.

ION Test Unit