the ENERGY lab

PROJECT FACTS

Carbon Capture

Bench-Scale Development of a Non-Aqueous Solvent (NAS) CO_2 Capture Process for Coal-Fired Power Plants

Background

The mission of the U.S. Department of Energy Office of Fossil Energy's (DOE FE) Carbon Capture Research & Development (R&D) Program, implemented through the National Energy Technology Laboratory (NETL), 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 from PC-fired plants 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

RTI's bench-scale solvent testing unit

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PARTNERS

Linde LLC

PROJECT DURATION

Start Date	End Date
10/01/2013	09/30/2015

COST

Total Project Value
$3,099,081

DOE/Non-DOE Share
$2,387,072/$712,009

PROJECT NUMBER

DE-FE0013865

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. Carbon dioxide capture processes based on non-aqueous solvents (NAS) may have lower parasitic power requirements and significantly reduce the cost of capturing CO_2 from PC-fired flue gas.

Project Description

Research Triangle Institute (RTI) is partnering with Linde LLC to continue the development of an NAS-based CO_2 capture process through bench-scale testing. Non-aqueous solvents have the potential to significantly reduce the cost of CO_2 capture from coal-fired flue gas when compared to aqueous amine–based solvent processes by reducing the energy required for solvent regeneration. The NAS CO_2 capture process was developed by RTI under a previous DOE/Advanced Research Projects Agency-Energy (ARPA-E)-funded project that identified several promising NAS formulations that showed potential for achieving low thermal regeneration energies and evaluated overall process stability at laboratory scale. The current bench-scale project will address key technical and economic challenges and uncertainties, including solvent makeup cost, scalable regenerator design for NAS, development of a complete NAS process arrangement, and improvement of capital cost estimate confidence that will enable the scale-up of the process and determine economic feasibility.

RTI will establish the best-candidate NAS formulation with specific emphasis on reducing solvent makeup costs by reducing the formulation cost and evaporative and degradation losses, while maintaining the desired CO_2 absorption chemistry. The project team will advance the design of the process by developing and evaluating the effectiveness of two process units specific to NAS: the NAS Recovery/Wash Section and NAS Regenerator. A comprehensive bench-scale testing campaign will be conducted to evaluate the thermal regeneration energy requirements and develop a detailed understanding of the operation of the NAS CO_2 capture process. An environmental, health, and safety (EH&S) risk assessment will be completed and a detailed techno-economic analysis will be conducted of a commercial-scale NAS CO_2 capture process based on experimental data from the bench-scale testing campaigns.

Primary Project Goal

The primary project goal is to further the advancement of the NAS CO_2 capture process by addressing specific technical and economic challenges and validate, through bench-scale testing, its potential to reduce the thermal regeneration energy associated with the capture of CO_2 from coal-fired flue gas, and make progress toward meeting the DOE goal to demonstrate second-generation technologies that can capture 90 percent of the CO_2 at less than $40 per tonne in the 2020–2025 timeframe.

Objectives

The specific objectives of this project are to minimize solvent makeup costs; collect detailed kinetic and thermodynamic characteristics of NAS; develop a rate-based model to be used to interpret data from the bench-scale testing campaign; develop and evaluate process components specific to the NAS CO_2 capture process; evaluate the NAS CO_2 capture process at the bench scale (complete with all major process components) using simulated coal-derived flue gas; and validate that the NAS are capable of achieving 90 percent CO_2 capture and generating a high-purity CO_2 product.

Planned Activities

- Refine the NAS formulation, conduct laboratory-scale testing, and perform a fundamental degradation study to identify the best candidate formulation with minimized make-up costs
- Upgrade existing laboratory equipment, develop the model framework, and conduct testing to collect equilibrium and reaction rate data to develop a rate-based model for the best-candidate NAS
- Increase the fidelity of the NAS process design through laboratory-scale development and evaluation of the solvent recovery and regenerator systems
- Design and modify an existing bench-scale system to include the NAS recovery and regenerator systems and complete calibration and commissioning tests
- Complete a parametric testing campaign with the bench-scale system to evaluate the best-candidate NAS and collect experimental data to support a detailed techno-economic analysis
- Complete solvent degradation studies of the best-candidate NAS to determine the impact of common reactive components other than CO_2 in the flue gas
- Complete development of the rate-based model, validate the model with experimental data, and use the model to interpret experimental data collected from bench-scale testing
- Perform techno-economic and EH&S analyses of the NAS CO_2 capture process

Accomplishments

The project was awarded in September 2013.

Benefits

Successful completion of bench-scale testing of the NAS CO_2 capture process will validate that the process has the potential to reduce the cost of capturing CO_2 from coal-fired power plant flue gas to less than $40 per tonne of CO_2 captured by 2025, primarily by reducing the regeneration energy of the process by 30 to 50 percent compared to state-of-the-art CO_2 capture processes.