the ENERGY lab

PROJECT FACTS

Carbon Capture

Pilot-Scale Silicone Process for Low-Cost Carbon Dioxide Capture

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/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 the competitiveness of fossil-based energy systems beyond 2035.

Post-combustion CO_2 capture technologies are applicable to conventional pulverized coal-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 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 costassociated with the capture and compression of CO_2. Carbon capture technologies developed under the DOE program may also be applied to natural gas power plants after addressing the R&D challenges associated with the relatively low concentration of CO_2 in the flue gas (typically 3–4 percent) of natural gas plants. A novel aminosilicone-based solvent has shown promising performance for post-combustion CO_2 capture.

Project Description

General Electric Global Research will further develop a novel silicone solvent for CO_2 capture via continuous testing with a pilot-scale system using actual flue gas. Experimental results from two previous DOE-funded projects will be used to design the pilot-scale system. The aminosilicone-based solvent system previously underwent laboratory-scale testing during project DE-NT0005310 and continuous bench-scale testing during project DE-FE0007502 to capture CO_2 from simulated coal-fired flue gas. The aminosilicone-based solvent has shown high thermal stability, high working capacity, low volatility, and low corrosivity, allowing for reduced parasitic power requirements and operating costs of the capture system as compared to monoethanolamine-based systems.

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PROJECT DURATION

Start Date	End Date
01/01/2014	12/31/2015

COST

Total Project Value
$5,702,075

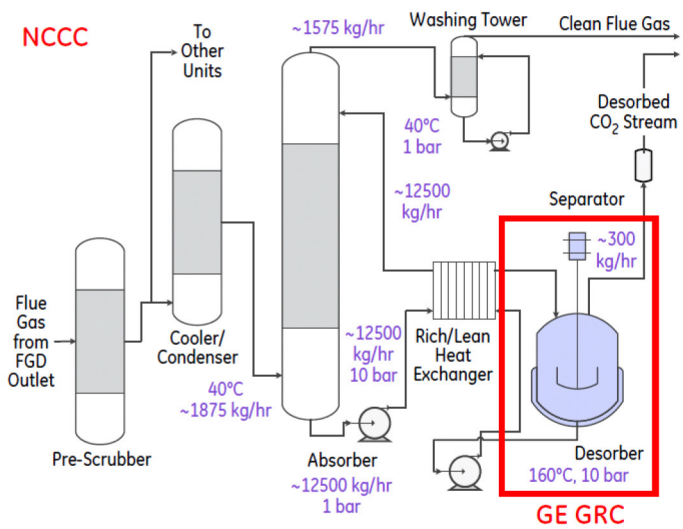
DOE/Non-DOE Share
$4,561,660/$1,140,415

PROJECT NUMBER

DE-FE0013755

The project team will scale up the aminosilicone-based CO_2 capture process from bench-scale to a slipstream pilot-scale system for continuous long-term testing. A 0.5 mega-watt electrical (MWe) pilot-scale system will be designed and built for testing the solvent system at the National Carbon Capture Center (NCCC) on actual coal-fired flue gas. Data obtained from the system will include mass transfer parameters, reaction rates, heat transfer parameters, solvent stability, effects of flue gas contaminants, and recommended operating conditions. The cost of the solvent at full scale will be estimated. The pilot-scale engineering data will be used to update the capture system process models.These models will be used to complete the techno-economic analysis and develop a scale-up strategy. A technology environmental, health, and safety (EH&S) risk assessment will also be completed.

- Design and install a 0.5 MWe pilot-scale system at the NCCC utilizing the aminosilicone-based CO_2 capture solvent
- Develop a test plan for a continuous CO_2 capture absorption/desorption system
- Conduct parametric and continuous testing to obtain engineering data
- Analyze the pilot-scale testing data
- Determine suitable materials of construction by analyzing test coupons inserted in the process
- Develop a cost estimate for full-scale manufacture of the aminosilicone-based solvent



Schematic of the pilot-scale system to be installed and operated at the NCCC.

Primary Project Goal

The overall project goal is to establish the scalability and technical and economic feasibility of using an aminosilicone-based CO_2 capture absorbent for post-combustion capture of CO_2 from coal-fired power plants while meeting the DOE goal of demonstrating 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 project objectives are to design, construct, and operate a pilot-scale unit to test the aminosilicone-based CO_2 capture solvent; obtain parametric data to determine key scale-up parameters; perform EH&S and techno-economic analyses to determine the feasibility of commercial-scale operations; and develop a scale-up strategy for the solvent system.

Planned Activities

- Perform preliminary techno-economic and EH&S analyses based on previous project results
- Perform technology EH&S risk assessment
- Perform a techno-economic analysis
- Develop a scale-up strategy for advancing the silicone CO_2 capture process toward commercialization

Accomplishments

The project was awarded in October 2013.

Benefits

The aminosilicone-based process has a number of advantages that decrease the energy penalty compared to other post-combustion carbon capture technologies, and the capital cost of the equipment for this process is expected to be lower than competitive technologies. Both benefits result in a lower cost for CO_2 capture. Development of a scalable process using a novel aminosilicone based solvent capable of meeting the DOE carbon capture goals, combined with a rigorous process model, will enable a practical technology path to later development at commercial scales. The technology will eventually be applicable for retrofitting existing coal-based power plants.