the ENERGY lab

PROJECT FACTS

ICCS - Area 2

Innovative Carbon Dioxide Sequestration from Flue Gas Using an In-Duct Scrubber Coupled with Alkaline Clay Mineralization

Background

The United States Department of Energy (DOE) is leading an effort to find novel approaches to reduce carbon dioxide (CO_2) emissions from industrial sources. The Industrial Carbon Capture and Sequestration (ICCS) program is funded by the American Recovery and Reinvestment Act (ARRA) to encourage development of processes that will convert CO_2 to useable products and fuels while mitigating CO_2 emissions in geographical areas where geologic storage may not be an optimal solution. To this end, the National Energy Technology Laboratory (NETL) is partnering with Alcoa, Inc. (Alcoa) to develop an innovative concept for capturing CO_2 and converting it to minerals for use as a benign soil additive.

Project Description

This project will demonstrate and optimize a process to capture CO_2 from industrial flue gas streams with in-duct scrubbers, convert it directly to carbonates and bicarbonates, and sequester it through alkaline clay mineralization. The process uses the captured CO_2 to convert an industrial waste, bauxite residue, into a beneficial soil amendment, carbonated alkaline clay.

During Phase 1 of this project, Alcoa defined the most efficient conditions for converting CO_2 from industrial flue gas into bicarbonates and for sequestering them as mineral carbonates using bauxite residue. Project tasks included (1) defining the most efficient conditions required for scrubbing greater than 75 percent of CO_2 from industrial flue gas by using a horizontal in-duct alkali scrubber; (2) defining the efficiency impact of coupling alkali scrubbing with carbonic anhydrase coated contactor(s) for converting CO_2 to bicarbonate and carbonate; (3) defining the conditions required for maximizing sequestration of bicarbonates and carbonates as mineral carbonates in bauxite residue; (4) defining the engineering parameters required to enable continuous operation of a coupled CO_2 conversion and sequestration process; and (5) conducting an economic analysis of the most efficient options for commercial-scale deployment.

To accomplish Phase 1, an in-duct scrubber system was installed at the Alcoa Technical Center to allow for laboratory evaluation and optimization of scrubber performance. Bauxite residue from Alcoa refineries were employed to allow lab-scale evaluations of process stream and mixing conditions on the sequestration rate and maximum sequestration capacity of bauxite residue under varying operating conditions.

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PROJECT DURATION

Start Date
10/15/2009

End Date
06/30/2013

COST

ARRA funded

Total Project Value
$16,872,967

DOE/Non-DOE Share
$13,498,746 / $3,374,221

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

AWARD NUMBER

FE0002415

During Phase 2, Alcoa will construct and operate the pilot-scale plant. This demonstration test will determine the ability to scale-up this carbon capture/sequestration process by a 15:1 ratio. The team will optimize operating conditions such that greater than 75 percent CO_2 removal is achieved from a boiler flue gas while demonstrating the generation of a beneficial use product (i.e., carbonate enhanced clay) and operation as a zero-waste process. At these operating conditions, engineering parameters including reaction rates and mass transfer rates will be calculated to permit an engineering and economic assessment of the commercial deployment of this carbon management strategy.

Goals and Objectives

The overall objective of the project is to demonstrate and optimize a commercially viable process for directly mineralizing CO_2 from industrial flue gas streams, and in so doing, convert a sequestration agent, a highly caustic industrial waste (bauxite residue), into a beneficial reuse product (carbonated alkaline clay). This would help to achieve the goal of economically reducing greenhouse gas emissions to decrease human effects on climate change. Phase 2 objectives will be achieved over the course of three years and include reviewing final Phase 1 data and developing a final design basis for the field pilot test; completing design, process reviews, and environmental permitting; completing equipment procurement, installation, and system start-up; and performing system optimization and demonstration. An additional objective is to conduct laboratory investigations of alkaline sequestration agents, bicarbonate slurry stripping, alkaline clay sequestration, and promising alternative sequestration agents.

Accomplishments

Alcoa has installed an in-duct scrubber system at the Alcoa Technical Center. The process has resulted in commercially viable method to directly mineralize CO_2 from industrial flue gas stream, while also converting the sequestration agent into a beneficial reuse product. Alcoa has defined and optimized the key process conditions required to enable continuous operation of the process to achieve the optimum reduction of greenhouse gas emissions, while maintaining an economically viable process for commercial scale.

Benefits

This project will reduce CO_2 emissions by using exhaust CO_2 to convert a high-volume, highly caustic waste product from aluminum production into a saleable soil-building product. Success of this project may result in wider industry interest in the system being developed. Adopting this technology would lead to significant cost-effective reductions in industrial greenhouse gas emissions and in the volume of alumina refinery waste products requiring remediation.

Alcoa In-Duct Scrubber Pilot